MOTOROLA

Service Manual
Level III

TIMEPORT™

DIGITAL WIRELESS TELEPHONE

Model P8190

TDMA 800MHz/Analog 800MHz

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About This Manual

Scope of Manual

This manual is intended for use by experienced technicians familiar with similar types of equipment. It is intended primarily to support basic servicing, which consists primarily of mechanical repairs and circuit board replacement.
Authorized distributors may opt to receive additional training to become authorized to perform limited component repairs. Contact your regional Customer Support Manager for details.

Model and Kit Identification

Motorola products are specifically identified by an overall model number on the FCC label. In most cases, assemblies and kits which make up the equipment also have kit model numbers stamped on them.

Service

Motorola regional Cellular Subscriber Support Centers offer some of the Þnest repair capabilities available to Motorola Subscriber equipment users. The Cellular Subscriber Support Centers are able to perform computerized adjustments and repair most defective transceivers and boards. Contact your regional Customer Support Manager for more information about MotorolaÕs repair capabilities and policy for in-warranty and out-of-warranty repairs in your region.

General Safety Information

Portable Operation

DO NOT hold the radio so that the antenna is very close to, or touching, exposed parts of the body, especially the face or eyes, while transmitting. The radio will perform best if it is held in the same manner as you would hold a telephone handset, with the antenna angled up and over your shoulder. Speak directly into the mouthpiece.
DO NOT operate the telephone in an airplane.
DO NOT allow children to play with any radio equipment containing a transmitter.

Mobile Operation (Vehicle Adaptor)

As with other mobile radio transmitting equipment, users are advised that for satisfactory operation of the equipment and for the safety of personnel, it is recommended that no part of the human body shall be allowed to come within 20 centimeters of the antenna during operation of the equipment.
DO NOT operate this equipment near electrical blasting caps or in an explosive atmosphere. Mobile telephones are under certain conditions capable of interfering with blasting operations. When in the vicinity of construction work, look for and observe signs cautioning against mobile radio transmission. If transmission is prohibited, the cellu-

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lar telephone **must be turned off** to prevent any transmission. *In standby mode,* the mobile telephone will automatically transmit to acknowledge a call if it is not turned off.
All equipment must be properly grounded according to installation instructions for safe operation.

Portable/Mobile Telephone Use and Driving

Safety is every driver's business. The portable telephone should only be used in situations in which the driver considers it safe to do so. Use of a cellular portable while driving may be *illegal* in some areas.
Refer to the appropriate section of the product service manual for additional pertinent safety information.

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Specifications

Table 1.Overall System

Function	*Specification*
Frequency Range	**TX (800MHz)** : 824.04 - 848.97 MHz Channels 1 to 799, f_{TX} = 0.03 * N+ 825MHz Channels 990 to 1023, f_{TX} = 0.03(N-1023)+ 825MHz **RX(800 MHz)**: 869.04 – 893.97 MHz Channels 1 to 799, f_{RX} = 0.03 * N+ 870MHz Channels 990 to 1023, f_{RX} = 0.03(N-1023)+ 870MHz
Channel Spacing	30 kHz
Channels	832 (800MHz)
Duplex Spacing	45 MHz (800MHz)
Input/Output Impedance	50 ohms (nominal)
Operating Voltage	+4.0 to +5.5Vdc (external connector)
Dimensions	5.1 cubic inches
Weight	3.6 ounces
Display	96x32 LCD display
Maximum RF Power Output	0.6 Watts (28 dBm)
Automatic Power Control	9, 4 dBm steps

Table 2. EAMPS System

Function	*Specification*
Modulation Type	FM
Frequency Stability	$\pm$ 2.5ppm
Duty Cycle	Continuous
Audio Distortion (transmit and receive)	Less than 5% at 1 kHz; $\pm$ 8 kHz deviation
FM Hum and Noise (C-MSG weighted)	32 dB below $\pm$ 8 kHz deviation @ 1 kHz
Voice Modulation	Maximum $\pm$ 12 kHz deviation
Transmit Audio Sensitivity	9 kHz deviation (nom.) @ 97 dB SPL input @ 1 kHz
Receive Sensitivity	-116 dBm for 12 dB SINAD (C-MSG weighted)
Adjacent and Alternate Channel Desensitization	-16 dB @ +30 kHz, -60 dB @ $\pm$ 60 kHz
IM	Greater than 65 dB

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Table 3. DAMPS System

Function	*Specification*
Modulation Type	π/4DQPSK
Frequency Stability	± 200 Hz
Duty Cycle	32.3%
Error Vector Magnitude (π/4DQPSK mode)	Error Vector Magnitude [Digital] 12.5%
Transmit Audio Sensitivity	TOLR of –46 dB nominal
Receive Sensitivity	-116 dBm for 3% static BER
Adjacent and Alternate Channel Desensitization	-116 dBm for 3% static BER
IM	Less than or equal to 3% static BER
Vocoder	ACELP

Table 4. Environment

Function	*Specification*
Temperature	-30ºC to +60ºC
Humidity	80% RH at 50ºC
Vibration	EIA PN1376
Shock	EIA PN1376

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Cellular Overview

Introduction

A cellular mobile telephone system divides the service area into small, low power radio frequency coverage areas called cells. A cellular system consists of a more or less continuous pattern of these cells, each having a 1 to 40 mile radius (typically 5 - 10 miles). Within each cell is a centralized cell site with an elevated antenna and a building. The building houses a base station with transceivers and related control equipment for the channels assigned to that cell. All the cell sites within a system are then connected either by dedicated land lines, microwave links, or a combination of both to a central control site called the central controller or switch .

The switch controls the entire cellular system and serves as the interface between the cellular telephone user and the landline network. Each cell site operates on an assigned access channel, and may have any number of paging and voice channels assigned to it.

Figure 1. Channel Assignments

A BAND	CHANNELS
Primary Control Channels (21):	313 - 333
Secondary Control Channels (21):	688 - 708
Voice Channels...	001 - 312,
(395 AMPS / 1185 NAMPS):	667 - 716, and 991 - 1023
B BAND	**CHANNELS**
Primary Control Channels (21):	334 - 354
Secondary Control Channels (21):	737 - 757
Voice Channels...	355 - 666 and
(395 AMPS / 1185 NAMPS):	717 - 799

NOTE:
In NAMPS applications, each AMPS voice channel provides space for three NAMPS voice channels. Digital cellular multiplexes voice channels to allow for the possibility of several additional conversations on a single channel.

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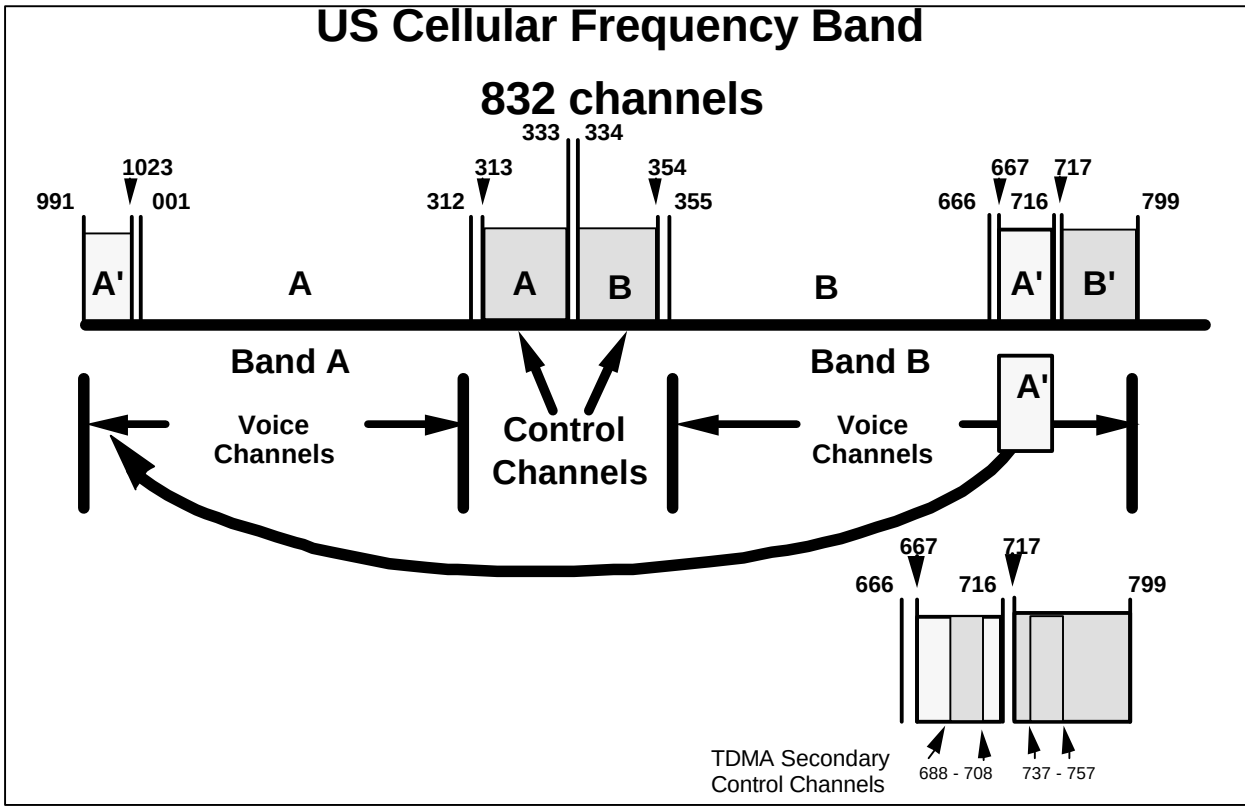
The cellular radio frequency spectrum has been divided by the FCC into two equal segments or bands to allow two independent cellular carriers to coexist and compete in the same geographic coverage area. Each band occupies one half of the available channels in the cellular spectrum. Initially there were 666 channels available across the entire cellular spectrum, but that number was expanded to 832 channels in 1987, and with NAMPS to 2,412 channels in 1991. Digital cellular promises to make a further expansion. To guarantee nationwide compatibility, the signaling channel frequencies have been pre-assigned to each segment (band). The two bands and their assigned channels are defined in Figure 1.

Originally the B Band was assigned to the telephone company (referred to by a euphemism, the Wireline carrier). The A Band, by default, was referred to as the Non-Wireline carrier, guaranteed competition to the telephone company. Today the terms Wireline and Non-Wireline have little meaning since telephone company carriers now operate A Band systems, and vice-versa.

Control (Data) Channels

A cellular telephone in the cellular system is under the indirect control of the switch, or central controller. The central controller uses dedicated control channels to provide the sig-

Figure 2. US Cellular Frequency Band



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naling required to establish a telephone call. Control channels are used to send and receive only digital data between the base station and the cellular telephone. Voice channels are used for both audio and signaling once a call is established. The 21 control channels in each band may be dedicated according to two different applications: access and paging channels.

The data on the forward control channel generally provides some basic information about the particular cellular system, such as the system ID and the range of channels to scan to find the access and paging channels. Access channels are used to respond to a page or originate a call. The system and the cellular telephone will use access channels where two-way data transfer occurs to determine the initial voice channel. Paging channels, if used, are the normal holding place for the idle cellular telephone. When a call is received at the central controller for a cellular telephone, the paging signaling will occur on a paging channel. In many systems both control channel functions will be served by the same control (access) channel for a particular cell. Only in very high density areas will multiple control (paging) channels be required.

Primary control channels are used by all types of telephones. Secondary control channels are only used by TDMA telephones, providing them with an improved probability of locking onto a TDMA control channel.

Voice Channels

Voice channels are primarily used for conversation, with signaling being employed as necessary to handle cell-to-cell hand-offs, output power control of the cellular radiotelephone, and special local control features. Data from the cell site (known as FORWARD DATA) and data from the mobile or portable (known as REVERSE DATA) is sent using frequency shift keying. In AMPS signaling, various control and response tones are used for a variety of applications to be described later. However, in NAMPS signaling, the signaling data and tones have been replaced by sub-audible digital equivalents that constantly ride underneath the audio. And, of course, in digital cellular, all signaling is digital.

Signaling Protocol

In 1983, when the Federal Communications Commission (the FCC) licensed cellular telephony, the signaling protocol used was AMPS. AMPS (Advanced Mobile Phone Service) was the invention of Bell Labs, the signaling protocol that was ultimately adopted by all the governments of the entire Western Hemisphere and, eventually, several other governments throughout the world.

Today, with the implementation of Narrow AMPS and TDMA, and the imminence of CDMA, it may seem that AMPS is out of date. The truth is that AMPS is very much alive, at the very core of all these traffic expanding alternatives to the original signaling protocol developed for conventional cellular telephony.

Under the original AMPS protocol there were 21 control channels assigned to each of two possible carriers in any metropolitan area, with a total of 333 channels assigned to each carrier. Prior to 1987 the FCC had allocated 312 channels to voice (voice, DTMF, or data)

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applications for each carrier. In 1987 the FCC expanded the cellular spectrum (Expanded Spectrum) from a total of 666 channels to 832 channels, allowing for an increase of 83 voice channels for each carrier. But the number of control channels remained constant, *21 control channels for each carrier*.

In 1991, responding to the demand for even more voice channels, Motorola introduced NAMPS (Narrow AMPS), expanding the voice channels by a factor of 3, assuming all subscribers are using NAMPS telephones. But one thing remained constant, there were *21 control channels for each carrier*.

In 1992, when Motorola tested its TDMA digital product, digitizing three communication links on each of 395 voice channels, one thing remained constant: there were still *21 control channels for each carrier*.

Leaving the control channels more or less untouched is the key to allowing telephones that are not capable of NAMPS or digital operation to have access to the system using the conventional AMPS scheme. In virtually every scheme (AMPS, NAMPS, or digital), each control channel has a bandwidth of 30 kHz and uses the signaling protocol, with minor variations for NAMPS and digital, developed for conventional AMPS

The primary difference between NAMPS and AMPS is that a NAMPS voice channel has a bandwidth of only 10 kHz, whereas an AMPS voice channel has a bandwidth of 30 kHz. In addition, NAMPS does not make use of certain control and response tones on voice channels as does AMPS, but uses digital equivalents instead.
As the name implies, the primary difference between digital cellular and AMPS is that all signals are digitized, including voice.

At a basic level, cellular telephony has two divisions: analog cellular and digital cellular. In the following section, analog cellular (AMPS and NAMPS) will be discussed. In the succeeding section, digital cellular will be treated.

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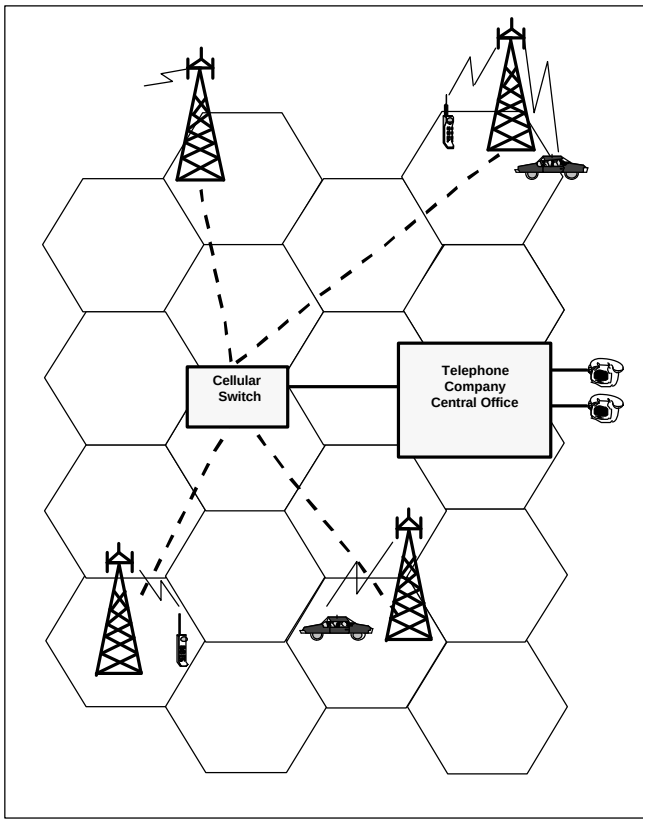
Analog Cellular

The simplified block diagram on page 1 - 7 illustrates an imaginary layout of one side (Band A, or Band B) of a hypothetical service area. The hexagons represent cells, and some of the cell sites shown here also illustrate the fact that an antenna tower and set of base stations are associated with each site. In a real world environment individual cells do not have the hexagonal shape but may take any form as dictated by the environment.

The cell sites are in communication with individual portable and mobile cellular telephones. These portables and mobiles may move from cell to cell, and as they do they are "handed off" under the supervision of the central controller (switch).

Figure 3. Channel Assignments



As illustrated(figure 3.) by the antenna tower on the upper left, cell sites transmit overhead messages more or less continuously even if there are no mobiles or portables active within that cell.

The switch (center left) is in control of the system and interfaces with the central office of the telephone company. As illustrated by the deskset telephones, the telephone company interfaces with the entire landline network.

The cell sites and the mobiles and portables communicate through the use of data or, in the case of AMPS, through the use of data and tones. A complete analysis of data signaling is beyond the scope of this manual. Refer to the Electronic Industries Association standard EIA-553 for a thorough discussion of AMPS signaling protocol, or to Motorola's NAMPS Air Interface Specification for NAMPS.

The tones used in AMPS signaling are Signaling Tones and Supervisory Audio Tones. NAMPS uses sub-audible digital equivalents.

Signaling Tone (ST) and Digital ST (DST)

In AMPS, signaling tone is a 10 kHz signal used by the mobile or portable on the reverse voice channel (REVC) to signal certain activities or acknowledge various commands from the cell site, including hand-offs, alert orders, and call terminations, and to indicate switch-hook operation. Various burst lengths are used for different ST activities. On NAMPS channels ST is replaced by a digital equivalent called Digital ST (DST) which is

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the complement of the assigned DSAT.

SAT (Supervisory Audio Tone) and DSAT (Digital SAT)

The Supervisory Audio Tone (SAT) is one of three frequencies around 6 kHz used in AMPS signaling. On NAMPS channels SAT is replaced by one of seven sub-audible digital equivalents or vectors called DSAT. SAT (or DSAT) is generated by the cell site, checked for frequency or accuracy by the cellular telephone, then transponded (that is, not merely reflected but generated and returned) to the cell site on the reverse voice channel (REVC). The cellular telephone uses (D)SAT to verify that it is tuned to the correct channel after a new voice channel assignment. When the central controller (switch) signals the mobile regarding the new voice channel, it also informs the mobile of the SAT frequency or DSAT vector to expect on the new channel. The returned (D)SAT is used at the cell site to verify the presence of the telephone's signal on the designated channel.

In general there are three uses of (D)SAT: (a) it provides a form of squelch; (b) it provides for call continuation (but if equipped for it, the switch will allow for VOX on all models); and (c) (D)SAT is used to prevent co-channel interference.

DTMF (Dual Tone Multi-Frequency)

DTMF (Dual Tone Multi-Frequency) touch-code dialing may also occur on voice channels. DTMF selects two tones from a total of nine (cellular only uses seven of these tones / four low and three high tones) to uniquely represent individual keys.

Figure 4. Channel Assignments

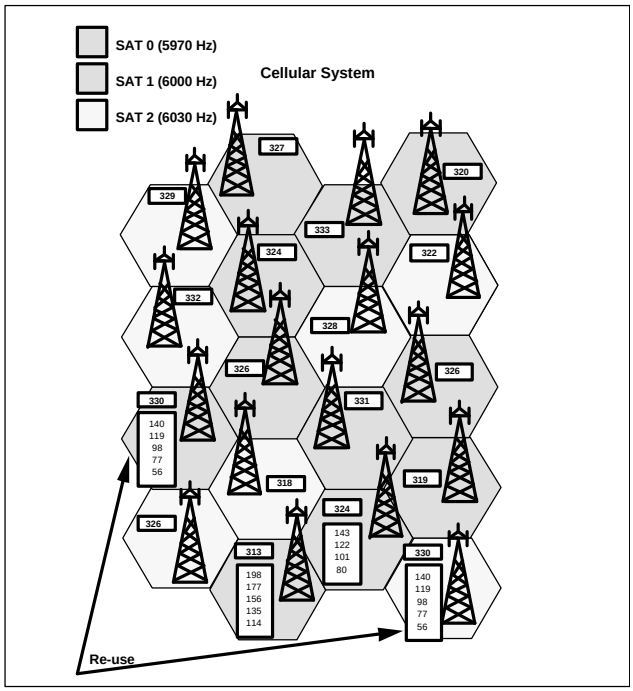

Table 6. DTMF Values

Key	Low Tone	High Tone
1	697	1209
2	697	1336
3	697	1477
4	770	1209
5	770	1336
6	770	1477
7	852	1209
8	852	1336
9	852	1477
*	941	1209
0	941	1336
#	941	1477

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Analog Cellular Signal Summary (AMPS and NAMPS)

The diagrams on the following pages outline the various uses of the signals employed in cellular systems. These signals include: SAT (Supervisory Audio Tone) 5970 Hz, 6000 Hz, or 6030 Hz. Used in AMPS for channel reuse, muting audio (squelch), and call continuation [typically ± 2 kHz deviation]. Digital SAT (DSAT) - One of seven codes or vectors used in NAMPS for the same purpose as SAT [± 700 Hz sub-audible NRZ data].

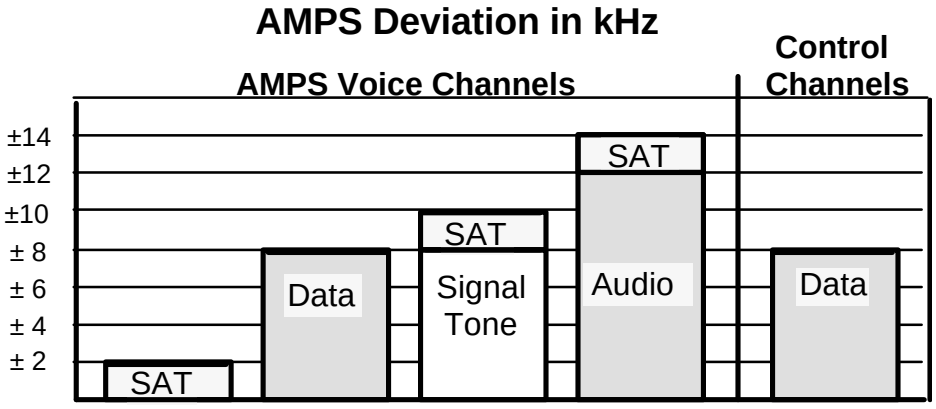
Data - Transmitted at 10 kilobits/second in AMPS and 200 bits/second in NAMPS. Data is used for sending System Orders and Mobile Identification. Do not confuse data with the 10 kHz signaling tone. In AMPS, data is transmitted as Manchester-encoded Frequency Shift Keying (FSK), where the carrier is shifted high or low 8 kHz, and the trailing edge transition is used to represent the logic. In NAMPS, data is transmitted as NRZ (Non-Return to Zero) FSK, where the carrier is shifted high or low 700 Hz, and the frequency shift itself is used to represent the logic.

Signaling Tone (ST) - A 10 kHz tone used in AMPS for mobile ringing, call terminations, hand-offs, and switch-hook operation [typically ± 8 kHz deviation]. ST is always accompanied by SAT.

Digital ST (DST) - One of seven digital equivalents of ST used on NAMPS channels. The transmitted DST is always the complement of the assigned DSAT [± 700 Hz sub-audible NRZ data].

Audio - Includes microphone audio and DTMF [maximum ± 12 kHz deviation AMPS, ± 5 kHz deviation NAMPS]. DTMF deviation should be measured on the radians scale; use key five looking for 9 radians. Audio is accompanied by SAT in AMPS signaling.

Figure 5. AMPS Deviation in kHz



Total deviation of two or more signals is cumulative.

Going into Service

When first turned on, the cellular telephone will scan through the nationwide set of forward control channels (FOCC's) and measure the signal strength on each one. It will then tune to the strongest one and attempt to decode the overhead control message. From the overhead message, the telephone will be able to determine whether or not it is in its home system, and the range of channels to scan for paging and access. Telephones not in their home system will be able to use other cellular telephone systems depending on the level of service requested by the user. If paging channels are used, the telephone next scans each paging channel in the specified range and tunes to the strongest one. On that channel the telephone continuously receives the overhead message information plus paging messages. At this point the telephone idles, continuously updating the overhead message information in its memory and monitoring the paging messages for its telephone number.

Step 1. The telephone powers up and runs a self-test. The NoSvc indicator is illuminated.

Step 2. The telephone scans its preferred system (A or B) as selected in programming.

Step 3. The telephone scans all twenty-one control channels.

Step 4. The telephone tunes to the strongest control channel.

Step 5. Decision point. Can the overhead message from the strongest control channel be decoded? If not, go to step 6. If it can be decoded go to step 8.*

Step 6. The telephone tunes to the second strongest channel.

Step 7. Decision point. Can the overhead message stream be decoded? If not, go to step 12. If it can be decoded, go to step 8.*

Step 8. Decision point. Does the decoded System ID match the Home System ID programmed in the telephone? If not, go to step 9. If it does match, go to step 10.

Step 9. The telephone turns on the ROAM indicator.

Step 10. The telephone turns off the NoSvc indicator.

Step 11. The telephone idles. Typically a rescan occurs after 5 minutes.

Step 12. The telephone turns on (or leaves on) its NoSvc indicator.

Step 13. The telephone switches to the non-preferred system as recorded in programming, and goes back to step 3. The ability to return to step 3 can be disabled by some settings of System Registration.

*The area between Decision point 5 and Decision point 8 can be quite active.
In a few larger systems, following the suc-

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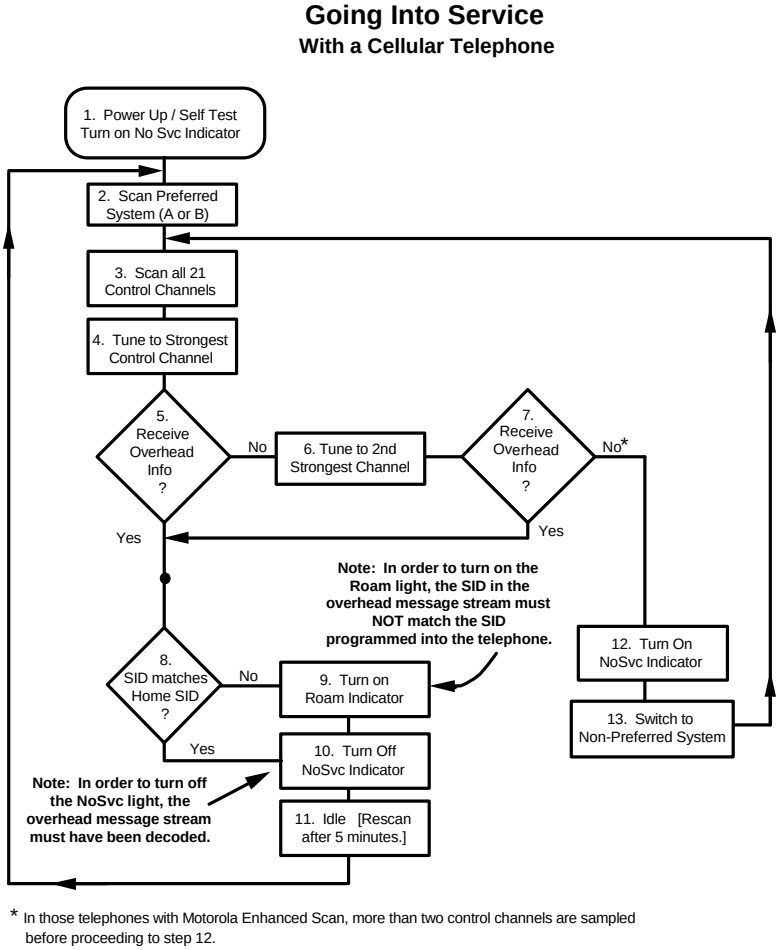
cessful completion of either steps 5 or 7, the telephone scans a set of paging channels, tunes to the strongest, and attempts to decode the overhead message train. The procedure is exactly equivalent to that followed for the access (control) channel. Also at this point, in a few larger systems, the telephone is commanded to identity itself (transmit) and thereby indicate its location in the system. This is called Autonomous System Registration and, like paging channels, is used to improve paging efficiency.

If the system employs Narrow AMPS, part of the overhead message stream is used to ask the for activity on one of the secondary or "digital" control channels, whereas a CDMA telephone will look for pilot signals. If digital signaling is not present, and if the telephone is capable of dual mode operation, it will default to AMPS mode.

Figure 6. Going into Serivce


Going Into Service
With a Cellular Telephone
1. Power Up / Self Test
Turn on No Svc Indicator
2. Scan Preferred System (A or B)
3. Scan all 21 Control Channels
4. Tune to Strongest Control Channel
5. Receive Overhead Info ?
No
6. Tune to 2nd Strongest Channel
7. Receive Overhead Info ?
No*
Yes
Yes
Note: In order to turn on the Roam light, the SID in the overhead message stream must NOT match the SID programmed into the telephone.
8. SID matches Home SID ?
No
9. Turn on Roam Indicator
Yes
10. Turn Off NoSvc Indicator
Note: In order to turn off the NoSvc light, the overhead message stream must have been decoded.
11. Idle [Rescan after 5 minutes.]
12. Turn On NoSvc Indicator
13. Switch to Non-Preferred System

* In those telephones with Motorola Enhanced Scan, more than two control channels are sampled before proceeding to step 12.

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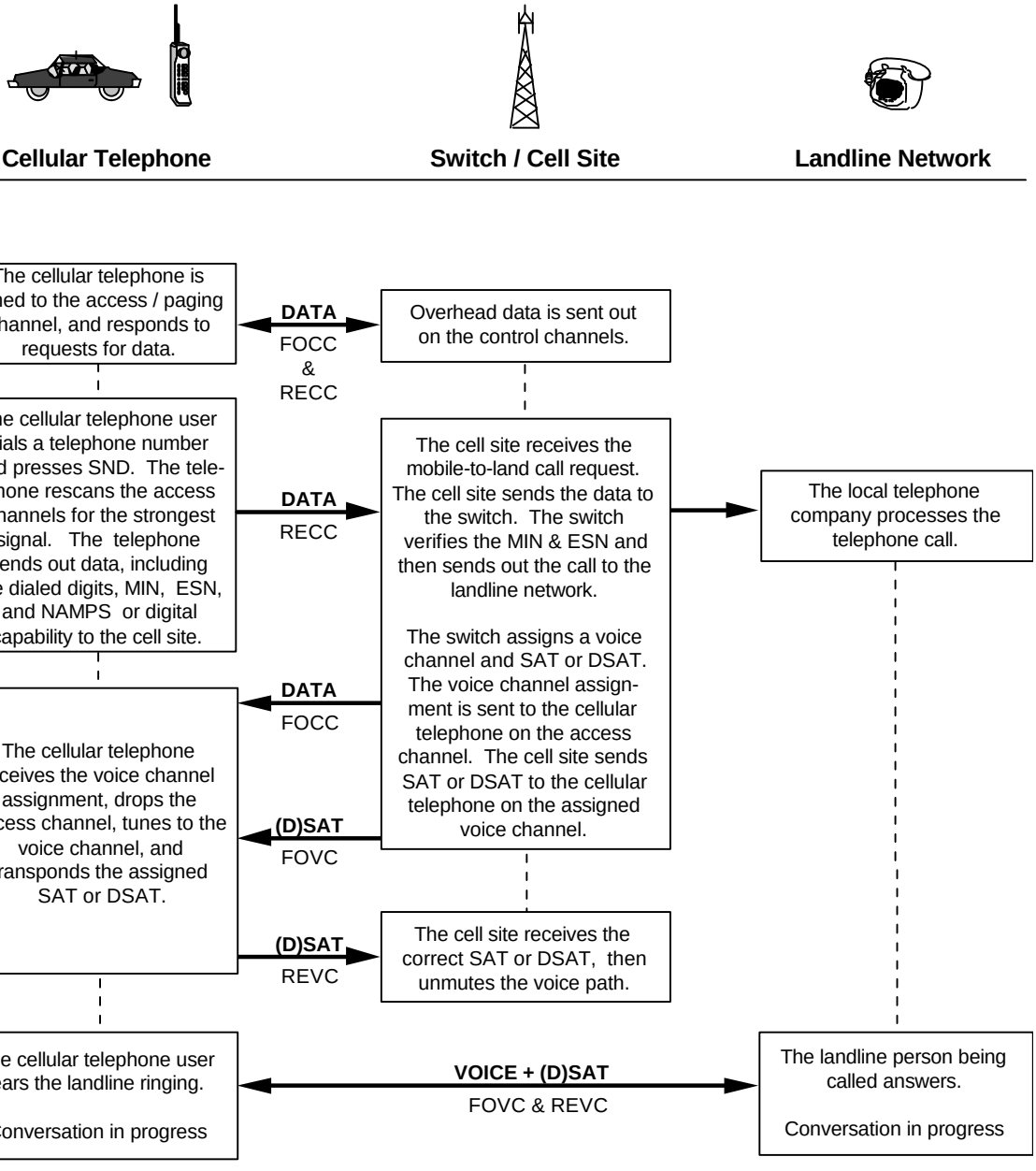
Placing a Call (Mobile to Land or Mobile to Mobile)

When the cellular telephone user originates the call, the cellular telephone re-scans the access channels to assure that it is still tuned to the strongest one. The cellular telephone then transmits data at the rate of 10 kilobits per second on the control channel to notify the switch of its mobile identification number (MIN) and the number it wants to reach. The switch verifies the incoming data and assigns a voice channel and a SAT (or DSAT for NAMPS channels) to the telephone.

Figure 7. Cellular Telephone to Land Call Processing


Cellular Telephone
Switch / Cell Site
Landline Network
The cellular telephone is tuned to the access / paging channel, and responds to requests for data.
DATA
FOCC & RECC
Overhead data is sent out on the control channels.
The cellular telephone user dials a telephone number and presses SND. The telephone rescans the access channels for the strongest signal. The telephone sends out data, including the dialed digits, MIN, ESN, and NAMPS or digital capability to the cell site.
DATA
RECC
The cell site receives the mobile-to-land call request. The cell site sends the data to the switch. The switch verifies the MIN & ESN and then sends out the call to the landline network.
The switch assigns a voice channel and SAT or DSAT. The voice channel assignment is sent to the cellular telephone on the access channel. The cell site sends SAT or DSAT to the cellular telephone on the assigned voice channel.
The local telephone company processes the telephone call.
DATA
FOCC
The cellular telephone receives the voice channel assignment, drops the access channel, tunes to the voice channel, and transponds the assigned SAT or DSAT.
(D)SAT
FOVC
(D)SAT
REVC
The cell site receives the correct SAT or DSAT, then unmutes the voice path.
The cellular telephone user hears the landline ringing.
Conversation in progress
VOICE + (D)SAT
FOVC & REVC
The landline person being called answers.
Conversation in progress

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The cellular telephone tunes to the assigned voice channel and verifies the presence of the proper forward SAT frequency (or DSAT message). If SAT (DSAT) is correct the telephone transponds SAT (DSAT) back to the cell site and unmutes the forward audio. The cell site detects reverse SAT (DSAT) from the cellular telephone and unmutes reverse audio. At this point both forward and reverse audio paths are unmuted and the cellular telephone user can hear the other end ring, after which conversation can take place. SAT (DSAT) is sent and received more or less continuously by both the base station and the cellular telephone. However, SAT (DSAT) is not sent during data transmissions, and the cellular telephone does not transpond SAT continuously during VOX operation. Also, DSAT is suspended during the transmission of DST. Notice that SAT and Signaling Tones are only used on AMPS voice channels, and that the Signaling Tone is only transmitted by the cellular telephone.

Receiving a Call (Land to Mobile)

Once a cellular telephone has gone into service, it periodically scans the overhead message information in its memory and monitors the paging messages for its telephone number. When a page match occurs the cellular telephone scans each of the access channels and tunes to the strongest one. The cellular telephone then acknowledges the page on that access channel and thus notifies the central controller of its cell location. The switch then assigns a voice channel and a SAT (DSAT) to the cellular telephone. The cellular telephone tunes to the voice channel, verifies the presence of the proper SAT frequency (DSAT message) and transponds the signal back to the cell site. At the cell site, the reception of SAT (DSAT) signals the central controller that the cellular telephone is ready for the call. An alert order is then sent to the cellular telephone which responds with a 10 KHz signaling tone (DST message). The subscriber unit rings for 65 seconds or until the user answers. Then the 10 KHz signaling tone (DST message) is terminated to alert the central controller that the user has answered. The switch then connects the incoming call to the appropriate circuit leading to the cell in contact with the cellular telephone. At this point both forward and reverse audio paths are unmuted and the conversation can take place. SAT (DSAT) is sent more or less continuously by the base station and transponded by the cellular telephone, except during data transmission. DSAT is suspended during DST transmission, and during VOX operation SAT (DSAT) is not transponded continuously by the cellular telephone.

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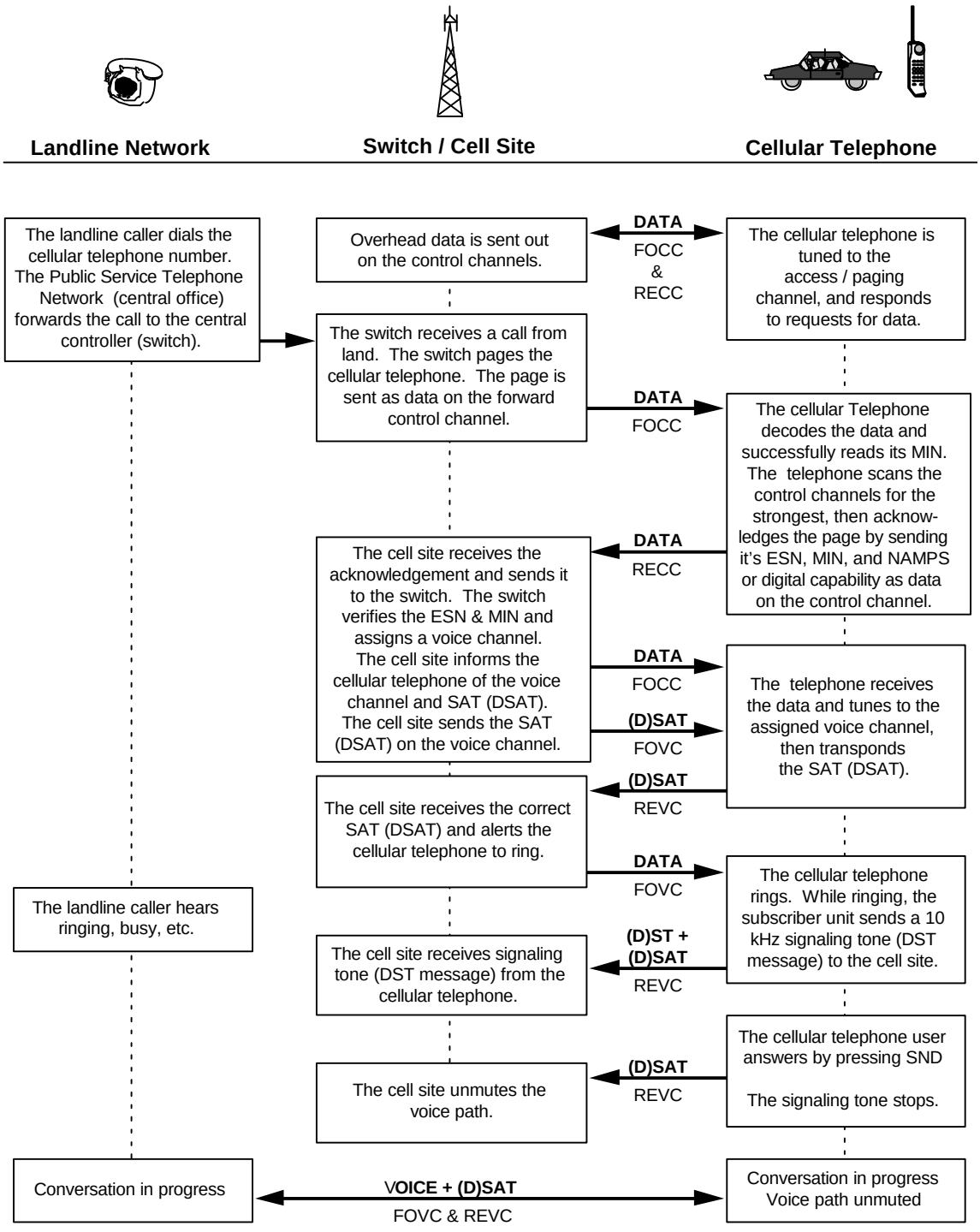
Figure 8. Land to Cellular Telephone Call Processing


Landline Network
Switch / Cell Site
Cellular Telephone
The landline caller dials the cellular telephone number. The Public Service Telephone Network (central office) forwards the call to the central controller (switch).
Overhead data is sent out on the control channels.
DATA
FOCC
&
RECC
The cellular telephone is tuned to the access / paging channel, and responds to requests for data.
The switch receives a call from land. The switch pages the cellular telephone. The page is sent as data on the forward control channel.
DATA
FOCC
The cellular Telephone decodes the data and successfully reads its MIN. The telephone scans the control channels for the strongest, then acknowledges the page by sending it's ESN, MIN, and NAMPS or digital capability as data on the control channel.
DATA
RECC
The cell site receives the acknowledgement and sends it to the switch. The switch verifies the ESN & MIN and assigns a voice channel. The cell site informs the cellular telephone of the voice channel and SAT (DSAT). The cell site sends the SAT (DSAT) on the voice channel.
DATA
FOCC
(D)SAT
FOVC
The telephone receives the data and tunes to the assigned voice channel, then transponds the SAT (DSAT).
(D)SAT
REVC
The cell site receives the correct SAT (DSAT) and alerts the cellular telephone to ring.
DATA
FOVC
The cellular telephone rings. While ringing, the subscriber unit sends a 10 kHz signaling tone (DST message) to the cell site.
The landline caller hears ringing, busy, etc.
(D)ST +
(D)SAT
REVC
The cell site receives signaling tone (DST message) from the cellular telephone.
The cellular telephone user answers by pressing SND
The signaling tone stops.
(D)SAT
REVC
The cell site unmutes the voice path.
Conversation in progress
VOICE + (D)SAT
FOVC & REVC
Conversation in progress
Voice path unmuted

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Power Steps

As a call progresses, the cell site continuously monitors the reverse channel for signal strength.

Every cellular telephone has a number of power steps ranging from full power (3 watts in a mobile and .6 watts in a portable) down to as low as about half a milliwatt. In reality all cellular telephones have eight power steps, but portable models are prevented from using the two highest power steps by the cell site. Transmit power level commands are sent to the cellular telephone as required to maintain the received signal strength within prescribed limits.

This is done to minimize interference possibilities within the frequency re-use scheme. If the signal received from the cellular telephone is higher than the prescribed limit (such as when the unit is very near the cell site), the subscriber unit will be instructed to step down to a lower level.

Hand-offs

If the cellular telephone is at its maximum allowed power for the cell site it is using and the received signal at the cell site is approaching the minimum allowable (typically -100 dBm), the cell site will signal the switch to consider the subscriber unit for a hand-off. The central controller (switch) will in turn have a scanning receiver at each of the surrounding cell sites measure the cellular telephone's signal strength. The site with the strongest signal will be the site to which the call will be handed to if there are available voice channels.

On an AMPS channel the hand-off is executed by interrupting the conversation with a burst of data (called blank and burst) containing the new voice channel assignment. The telephone acknowledges the order by a 50 millisecond burst of 10 kHz signaling tone on the originally assigned voice channel. The mobile telephone then drops the original voice channel and tunes to the newly assigned voice channel, keying up on that channel and transponding the assigned SAT. But on a NAMPS channel the hand-off is executed with a low speed data transmission that does not interrupt the voice. The telephone acknowledges the order in this case by a DST message. In either case, once the hand-off has been accomplished, the newly assigned cell site then alerts the switch that the hand-off has been completed, and the old voice channel is dropped.

It should be noted that this data exchange happens very quickly, lasting only as long as 260 milliseconds. However, when data or signaling tones are transmitted, audio is muted for the duration of that transmission and a syllable or two may be dropped from conversation. This is normally not a problem, but during data signaling, such as that employed for telefacsimile, answering machine, and computer communications, significant amounts of information may be lost. For this reason it is recommended that when THE Cellular Connection™ equipment is used the vehicle should be stationary to avoid data loss during hand-offs and other data transmissions. Otherwise the equipment should employ an error correction protocol.

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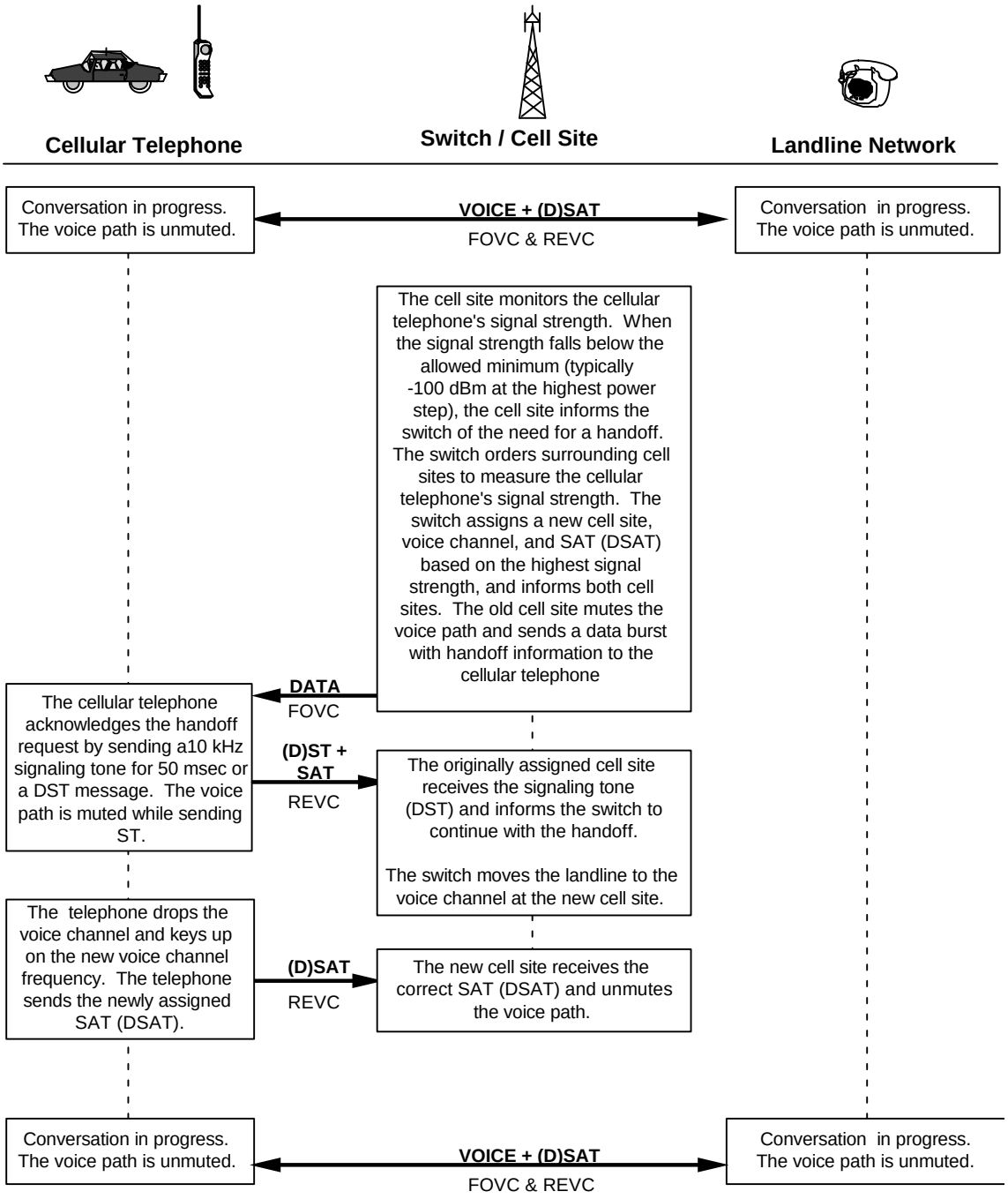
Figure 9. Cell Site Handoffs


Cellular Telephone
Switch / Cell Site
Landline Network
Conversation in progress. The voice path is unmuted.
VOICE + (D)SAT
FOVC & REVC
Conversation in progress. The voice path is unmuted.
The cell site monitors the cellular telephone's signal strength. When the signal strength falls below the allowed minimum (typically -100 dBm at the highest power step), the cell site informs the switch of the need for a handoff. The switch orders surrounding cell sites to measure the cellular telephone's signal strength. The switch assigns a new cell site, voice channel, and SAT (DSAT) based on the highest signal strength, and informs both cell sites. The old cell site mutes the voice path and sends a data burst with handoff information to the cellular telephone
DATA
FOVC
The cellular telephone acknowledges the handoff request by sending a10 kHz signaling tone for 50 msec or a DST message. The voice path is muted while sending ST.
(D)ST + SAT
REVC
The originally assigned cell site receives the signaling tone (DST) and informs the switch to continue with the handoff.
The switch moves the landline to the voice channel at the new cell site.
The telephone drops the voice channel and keys up on the new voice channel frequency. The telephone sends the newly assigned SAT (DSAT).
(D)SAT
REVC
The new cell site receives the correct SAT (DSAT) and unmutes the voice path.
Conversation in progress. The voice path is unmuted.
VOICE + (D)SAT
FOVC & REVC
Conversation in progress. The voice path is unmuted.

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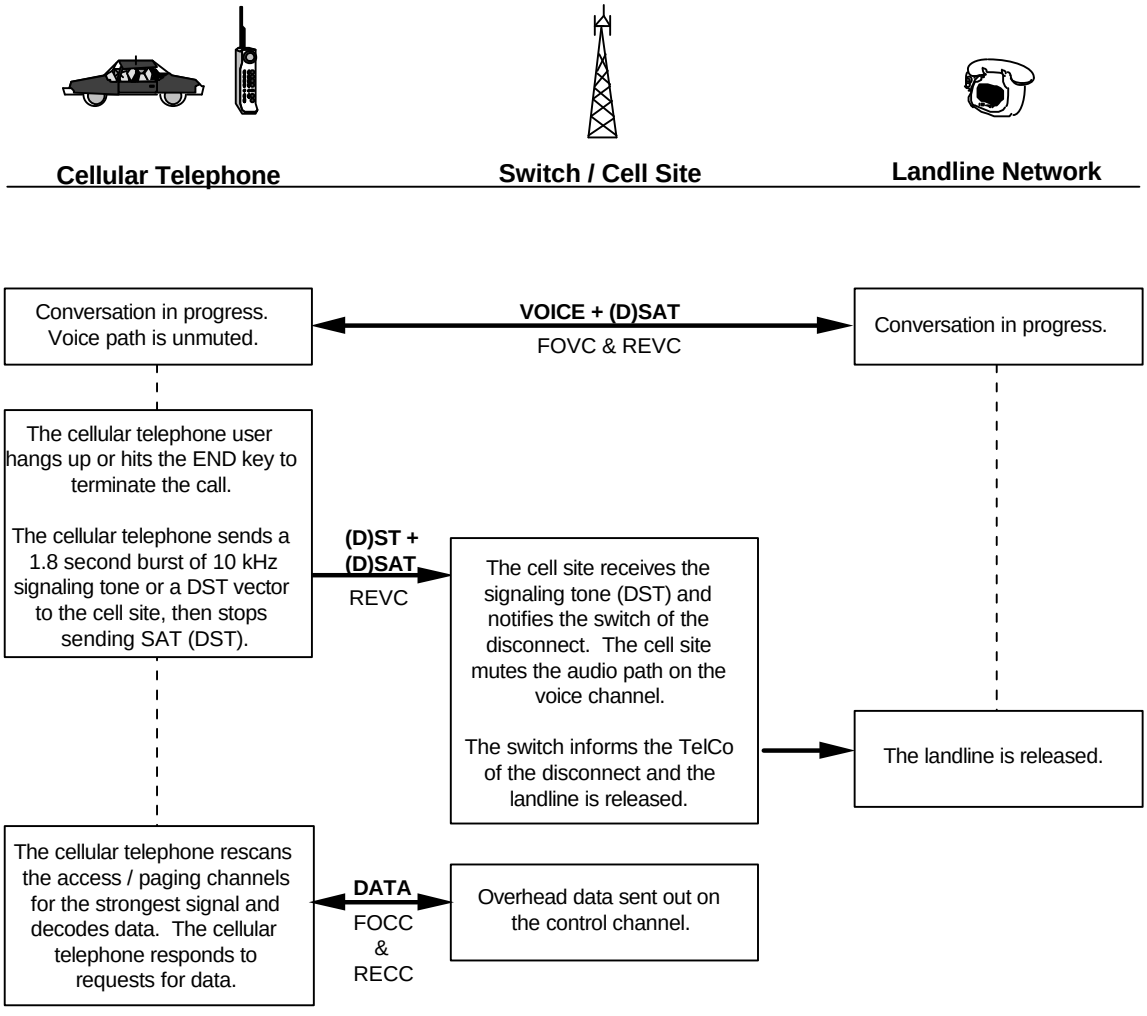
Call Termination

When the call is terminated by the landline caller (not the cellular telephone user), the central controller (switch) issues a release order to the subscriber unit. The cellular telephone acknowledges with a 10kHz signalling tone burst for 1.8 seconds and the cellular telephone ceases transmission.

If the call was terminated by the cellular telephone user, the telephone generates a 10kHz signalling tone burst for 1.8 seconds, indicating a call termination request to the switch. In either case after call termination, the cellular telephone goes back to rescan the nationwide set of forward controlchannels and repeats the Going into Service process it performed at first turn-on to re-establish itself on a paging channel.

Figure 10. Cellular Telephone Call Processing Termination


Cellular Telephone
Switch / Cell Site
Landline Network
Conversation in progress. Voice path is unmuted.
VOICE + (D)SAT
FOVC & REVC
Conversation in progress.
The cellular telephone user hangs up or hits the END key to terminate the call.
The cellular telephone sends a 1.8 second burst of 10 kHz signaling tone or a DST vector to the cell site, then stops sending SAT (DST).
(D)ST + (D)SAT
REVC
The cell site receives the signaling tone (DST) and notifies the switch of the disconnect. The cell site mutes the audio path on the voice channel.
The switch informs the TelCo of the disconnect and the landline is released.
The landline is released.
The cellular telephone rescans the access / paging channels for the strongest signal and decodes data. The cellular telephone responds to requests for data.
DATA
FOCC & RECC
Overhead data sent out on the control channel.

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Digital Cellular

Multiplexing

Using a single frequency to carry two or more communication links (e.g., conversations) is called multiplexing. There are two types of multiplexing that are feasible for cellular: code division multiplexing and time division multiplexing. Both code division multiplexing and time division multiplexing digitize voice before transmitting the signal. Another type of multiplexing, frequency division multiplexing, was briefly considered, then abandoned. We will deal with each type of multiplexing separately.

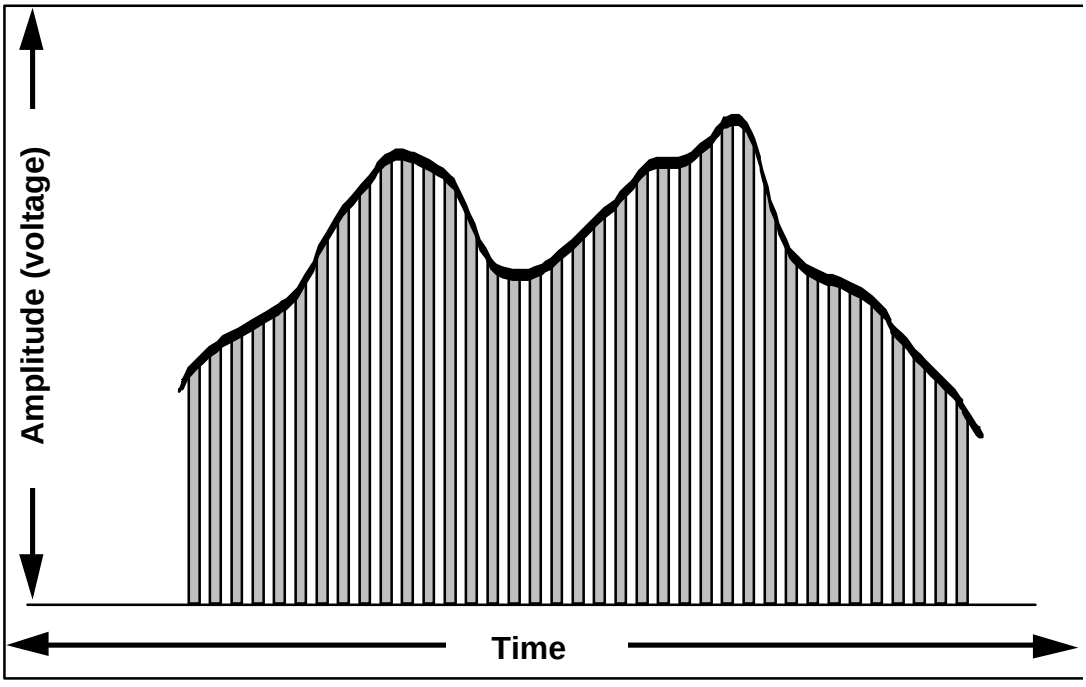
FDMA (Frequency Division Multiple Access)

Frequency Division Multiple Access (FDMA) uses two or more modulated subcarriers to modulate a third true carrier simultaneously. While as many as six communication links can be accommodated on a single frequency with FDMA, the bandwidth requirements are enormous. Given the relatively small 30 kHz bandwidth of cellular, FDMA was never a contender for improving the load carrying capacity of cellular systems. Also, it should be pointed out that FDMA is not necessarily digital.

Digitizing Voice

If a person speaks into a microphone, a transducer in the microphone converts the mechanical air movements produced by the person's vocal cords into varying voltages. If an oscilloscope probe is connected to the output from a microphone, a varying voltage

Figure 11. Digitizing Voice



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line, such as that shown in the accompanying illustration, will be produced.

If the varying voltages are sampled at some rate, the instantaneous voltages can be quantified. Let's say we want to quantify measurements from values of zero to 255 (the maximum value a binary byte can hold). The value of 255 would represent the highest possible voltage we could expect from voice, and zero would represent silence. Each discrete integer between zero and 255 would represent a particular voltage, typically presented in binary form.Because of the redundancies of speech and the inability of the human ear to detect more than a fraction of the intelligence in speech, it is possible to sample a small portion of the sound produced by a person speaking, reproduce that sound at either a later time or another place, then filter the resulting reproduction to produce a "sound" that is indistinguishable from the original source.

In the illustration on page 1 - 19 we saw how speech could be sampled at some rate. Suppose we take only one of every three samples. If our sampling rate is fast enough, and if we can compress the samples, it turns out that we can interleave several different conversations (communication links) on a single frequency. However, we also have to provide some mechanism for ensuring that the transmitter and receiver are in synchronization, and we have to provide for some alternative to the control and response tones used in conventional AMPS. All of these non-voice signals are digital and take time from the assigned time slot, leaving only a relatively small amount of time to represent voice. For this reason the digital receiver has to filter the audio to closely approximate the original audio.

TDMA (Time Division Multiple Access)

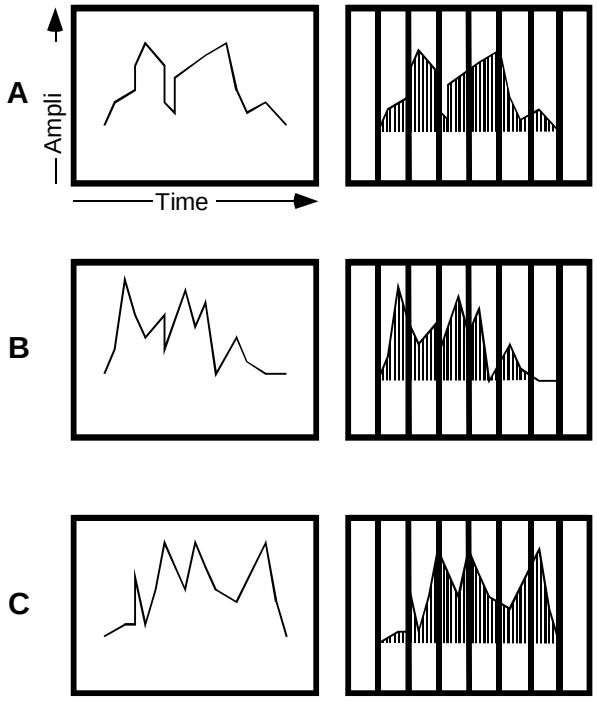
Time Division Multiple Access (TDMA) today provides a times-3 increase in the number of communication links a channel can carry (just like NAMPS). Eventually TDMA is expected to take full advantage of all six time slots, allowing for six communications links in the bandwidth of a conventional AMPS channel.

TDMA, like CDMA, employs a form of phase shift keying to represent symbols. However, TDMA also compresses the digitized signal, making use of predictive algorithms to reduce the number of symbols actually transmitted.

Digitization and TDMA

Here three conversations, represented by

Figure 12. Digitization and TDMA



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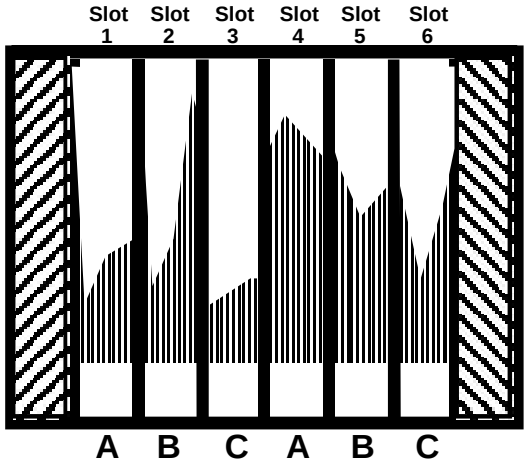
voice samples as viewed on oscilloscopes, are clearly shown to be nothing more than varying voltages produced by microphones. Instantaneous samples are discrete voltages. It has been shown that if the sampling rate is fast enough, it is possible to make a faithful representation of each conversation.

If these samples are then compressed, it is possible for more than a single conversation to occur on a single medium (such as a radio frequency) by sharing time slots. Here we see three conversations being shared on six time slots. The conversations shown are compressed sampled analog audio, not yet digitized.

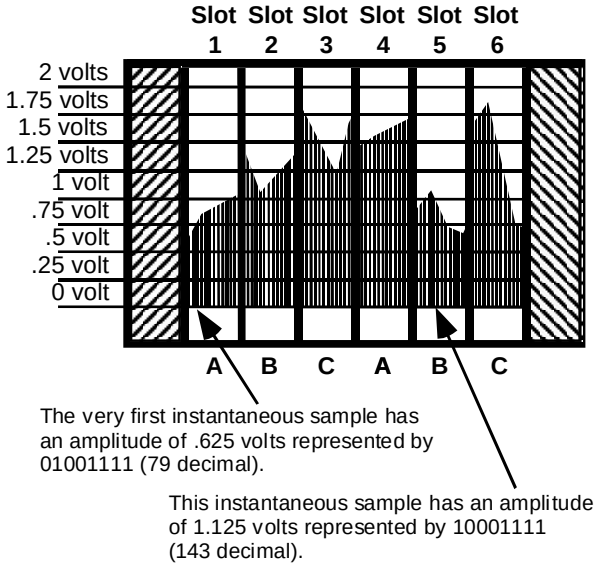
Figure 13. Slot Assignments



Digitization of Voltage

A byte, consisting of 8 bits, holds 256 possible numbers (0 through 255). If the maximum voltage we might expect from our voice samples is 2 volts, we can arbitrarily match those voltages proportionally to our byte. The result is a binary string representing voltages. We now have digital voice.

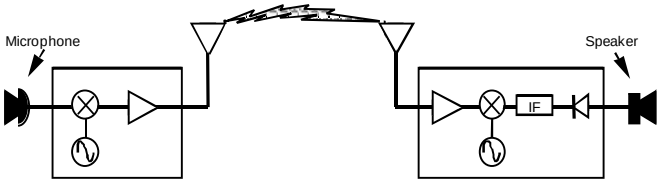
Figure 14. Digitization of Voltage



Conventional Radio

Radio uses transmitters to convert speech to radio energy and receivers to convert radio energy back to speech. In conventional analog radio, speech is converted into varying voltages called audio by a microphone. The

Figure 15. Convetional Radio



audio is mixed with a carrier frequency, amplified, and propagated through space as radio energy by an antenna. At the remote receiver an antenna converts the received radio energy to varying voltages at radio frequencies. The RF energy is beat against the output from a local oscillator to produce a difference frequency called the intermediate

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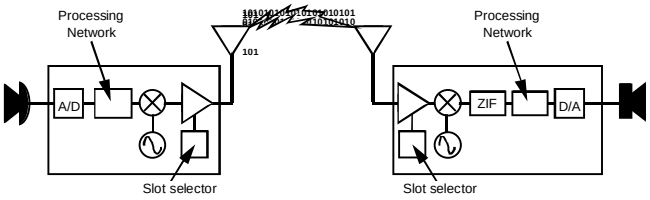
frequency. The IF is processed in the IF strip, which provides filtering and amplification. A discriminator retrieves audio from the IF and the varying voltages of the audio are used to drive a speaker

TDMA Radio

TDMA radios use the same circuitry as analog radios, for the most part, but also have additional circuitry to convert analog audio to digitized form and vice versa, and to select the appropriate time slot.

Figure 16. TDMA Radio



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Accessories

Desktop Charger

Rapid Desktop Charger Single Pocket
SPN4*641*

Travel Charger (Power Adapter)

U.S. SPN4604

ARGENTINA. SPN4647

HONG KONG. SPN4659

PRC. SPN4654

KOREA. SPN4688

BRAZIL. SPN4609

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Vehicle Power Adapter (VPA)

VPA. SYN4241

Headset

Jewel Case SYN7453

Hands-Free Car Kit

Panther redesign HUC S6965

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Easy Installation Car Kit

Zero Install Car Kit SYN8130

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TDMA Easy NAM Programming

Introduction

The Number Assignment Module (NAM) is a section of memory that retains information about the phone's characteristics, such as the assigned telephone number, system identification number, and options information.

Two methods are available to program the NAM using the keypad: Test Mode and User Mode.

Regardless of the method used, the NAM must be programmed before the phone can be placed into service. This chapter covers the NAM Programming steps for Easy NAM Programming which is the preferred programming method

User Mode Programming

User Mode NAM programming requires a special key sequence to enter, but can be accomplished through the telephone keypad without the use of any specialized hardware.

The telephone number can be changed up to fifteen times, after which the phone must be reset in Manual Test Mode using the **32#** command (erasing all repertory memory and initializing counters).

Some models may be available with a "User Mode NAM Programming Manual" which describes the entry key sequences and the programming steps for User Mode NAM programming.

User Mode NAM programming steps are different from Test Mode NAM programming steps, and do not include all of the option bits available in Test Mode NAM programming.

Access to User Mode NAM programming can be disabled by Test Mode NAM programming step 11, bit C7. Detailed description on Test Mode NAM Programming can be found in the TDMA ST7797 Level 2 and Level 3 Service Manual.

The following page describes the step by step procedure for Easy NAM Programming, which is the preferred programming method.

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Programming Sequence

Enter Programming Mode ❶ Press (# ►) , carrier system ID (from your Cellular Service Provider), (# ►) , (◄ *) , (snd). Phone displays " NAM 1 Prog * = Yes # = No".

❷ Press (◄ *). Display prompts for Security Code "_ _ _ _ _ _".

Enter Security Code ❸ Press (0+),(0+),(0+),(0+),(0+) , (0+) (factory set). Phone displays ESN (Electronic Security Number).

❹ Press (snd) . Phone prompts for Phone Number " Phon # _ _ _ _ _ _ _ _ _ _".

Enter Phone Number ❺ Enter the entire Phone Number "_ _ _ _ _ _ _ _ _ _". Press (SEND) Phone displays " NAM Program Begins ".
The phone will turn off. When you turn the phone back on, the phone number will be programmed.

Programming a second No. Press (# ►), carrier system ID , (# ►), (2 ABC) , (# ►) , (◄ *) , (SEND).
Continue with steps ❷ - ❺ .
Be sure to check with the carrier of the second telephone number for the system ID.

If you make a mistake Try again will appear and you can re-enter the number. Press (CLR) to erase a single digit or press and hold (CLR) to erase the entire entry. Press (snd) when you are finished.

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TDMA Test Mode NAM Programming

Introduction

The Number Assignment Module (NAM) is a section of memory that retains information about the phone's characteristics, such as the assigned telephone number, system identification number, and options information.
Two methods are available to program the NAM using the keypad: Test Mode and User Mode.

Regardless of the method used, the NAM must be programmed before the phone can be placed into service. This chapter covers the NAM Programming steps for Test Mode NAM Programming.

Entering Test Mode NAM Programming

The recommended Manual Test Mode setup for NAM programming phones are described in "Entering Manual Test Mode" on page 33. Refer to "Test Connections" on page 38 to see the recommended test setup for performing Servicing Level manual tests.

The phone is in Status Display mode after powering up in Manual Test mode. To enter NAM Programming mode, first press the # key for at least two seconds to suspend the Status Display. Then enter 5 5 #. The phone will now be in Step 1 of the NAM.

NAM Programming Steps

There are 19 steps in the NAM. For each step, the display shows factory default NAM data. When new data is entered via the keypad the display scrolls from left to right.

Use the * key to sequentially step through the NAM data fields, entering new data as required, or skipping past factory default values for parameters that do not need to be changed.

Table 7, "Minimum Required Test Mode NAM Programming Steps", shows the minimum required Test Mode NAM programming steps. The programming steps not listed in this table can be "stepped through", retaining the factory default values for those steps.

Table 8, "Test Mode NAM Programming Sequence," on page 3 lists all NAM programming steps, complete with parameters and definitions.

Table 7. Minimum Required Programming Steps

Service Type	Minimum Required Programming
Single NAM	1, 3, 4, 6, 9
Dual NAM Enable	11
Dual NAM	1, 3, 4, 6

NAM Data

NAM Data is specified by the system operator. For most NAM steps, the information specified by the system operator is the same as the factory default data.

The factory default System ID (step 01) and User Telephone Number (step 03) must always be changed.

Other portions of the factory default NAM data must sometimes be modified to conform to special system requirements, or to enable/ disable certain features.

If a second phone number is to be programmed, step 11 C Option Byte, bit 6 must be set to 1. This bit enables dual-NAM operation and will cause NAM program-ming steps 1-6, 12, and 16 to be repeated for the second phone number.

User Mode Programming

User Mode NAM programming requires a special key sequence to enter, but can be accomplished through the telephone keypad without the use of any specialized hard-ware. The telephone number can be changed up to fifteen times, after which the phone must be reset in Manual Test Mode using the 32# command (erasing all repertory memory and initializing counters).

Some models may be available with a "User Mode NAM Programming Manual" which describes the entry key sequences and the programming steps for User Mode NAM programming.

User Mode NAM programming steps are different from Test Mode NAM programming steps, and do not include all of the option bits available in Test Mode NAM programming. Access to User Mode NAM programming can be disabled by Test Mode NAM programming step 11, bit C7.

NOTE

Changed NAM values are not stored until pressing ***** after Step 19 (Step 16 if a second phone number was entered.)

IMPORTANT

Consult with the System Operator regarding NAM information. Incorrect
NAM entries can cause the phone to

Test Mode NAM Programming Sequence

Advances to the next programming step; also programs the NAM after the last programming step is entered.

Clears the entered information and displays previously entered data for the current programming step.

Exits the programming mode without programming the NAM.

Table 8. Test Mode NAM Programming Sequence

Step	Factory Default	Description
01	00000	**System ID Number**. Number assigned by system operator for system identification.
02	10110101 (A7-A0)	**A OPTION BYTE.** The display for step 02 represents the status of eight options, A7 through A0. Bit A7 (msb) is programmed first, followed by A6-A0. Bits enter display on the right and scroll left.
	1	**Local Use (Bit A7).** If set to 1 phone will respond to local control orders in the home area or when the group ID is matched. Assigned by system operator.
	0	**Preferred System (Bit A6).** Applies to units capable of operating on two service systems (A or B). 0 = system B; 1 = system A.
	1	**End-to-End Signaling (Bit A5).** When enabled, the phone is equipped for DTMF signaling during a call. 1 = enabled, 0 = disabled.
	1	**Authentication Enable (Bit A4).** Enter 1.
	0	**Bit not used (Bit A3).** Enter 0.
	1	**Auxiliary Alert (Bit A2).** When enabled, the user can place an Extended System in auxiliary alert mode and be notified of incoming calls via headlights, horn etc. 1 = enabled, 0 = disabled.
	0	**Bit not used (Bit A1).** Enter 0.
	1	**MIN MARK (Bit A0).** Supplied by system operator. When enabled the user's area code will be sent with each call initiated or answered. 1 = enabled, 0 = disabled.
03	0000000000	**User 10 digit radiotelephone phone number.** Number is assigned by system operator.
04	00	**Station class mark.** A 2 digit number assigned by the system operator. Indicates maximum power step, VOX capability, and number of channels used.
05	00	**Access overload class.** Specifies the level of priority assigned to the phone when accessing the system. Assigned by system operator.
06	00	**Systems group ID mark.** Specifies how many bits of the system ID are compared during call processing. Assigned by system operator.

Table 8: Test Mode NAM Programming Sequence (con't)

07	000000	**Security code.** A 6 digit number supplied by the user. This number is used by the user to access or change "security" features such as the 3-digit unlock code or the service level.
08	123	**Unlock code.** A 3 digit number supplied by the user. If the lock feature is enabled by the user, the phone can be operated only by individuals who know the unlock code.
09	4	**Service level.** This 3 digit number supplied by the user allows various call placement restrictions if desired. 004 = no restrictions.
10	00000100 (B7-B0)	**B OPTION BYTE** The display for step 10 represents the status of eight options, B7 through B0. B7 (msb) is programmed first followed by B6-B0. Bits enter display on the right and scroll left.
	0	**Bit not used (Bit B7).** Enter 0.
	0	**Bit not used (Bit B6).** Enter 0.
	0	**Bit not used (Bit B5).** Enter 0.
	0	**Bit not used (Bit B4).** Enter 0.
	0	**Single System Scan (Bit B3).** If set to 1, phone will scan only one system based on the setting of the preferred system bit (option bit A6). 1 = enabled, 0 = disabled.
	1	**Auto Recall (Bit B2).** When set to one, the user may access repertory by a one or two digit send sequence (speed dialing).
	0	**Disable Service Levels (Bit B1).** If set to 1, the service level (call restrictions) cannot be changed by the user.
	0	**Lock Disable (Bit B0).** When set to 1, the user cannot lock and unlock the phone unit via the 3 digit lock code.
11	00001000 (C7-C0)	**C OPTION BYTE** The display for step 11 represents the status of eight options, C7 through C0. C7 (msb) is programmed first followed by C6-C0. Bits enter display on the right and scroll left.
	0	**User Mode NAM Programming Disable (Bit C7).** When set to 1, User Mode NAM programming cannot be accessed.
	0	**Second Number Registration (Bit C6).** When set to 1, allows access to the second phone number.
	0	**Bit not used (Bit C5).** Enter 0.
	0	**Auto Redial Disable (Bit C4).** When set to 1, the user cannot access the 6-minute auto redial feature.
	1	**Speaker Disable (Bit C3).** This bit is used to disable internal handset speaker when adding V.S.P. option. 1 = handset speaker disabled, 0 = handset speaker enabled.
	0	**Bit not used (Bit C2).** Enter 0.
	0	**Selectable System Scan Disable (Bit C1).** When set to 1, the user cannot select the primary system.
	0	**Diversity Antenna Enable (Bit C0).** (Extended systems only) 0 = Non-diversity, 1 = Diversity.
12	0334	**Initial Paging System.** There are 4 significant bits for the initial paging channel. For system A enter 0333 and system B enter 0334.

Table 8: Test Mode NAM Programming Sequence (con't)

13	0333	**Initial A system channel.** To initialize system A enter 0333.
14	0334	**Initial B system channel.** To initialize system B enter 0334.
15	021	**Dedicated Paging Channels.** Number of dedicated paging channels is 21. Enter 021.
16	0737	**Secondary Initial Paging System.** There are 3 significant bits for the secondary initial paging channel. For system A enter 708 and system B enter 737. . Secondary initial paging channels are for digital applications, providing a secondary scan for a digital channel.
17	0708	**Secondary Initial A system channel.** To initialize system A enter 708.
18	0737	**Secondary Initial B system channel.** To initialize system B enter 737.
19	10111011	**D Option Byte.** The display for step 16 represents the status of eight options, D7 through D0. D7 (msb) is programmed first, followed by D6-D0. Bits enter display on the right and scroll to left.
	1	**Enhanced Scan Enable (Bit D7).** Enter 1.
	0	**Cellular Connection Enable (Bit D6).** Normally set to 0.
	1	**Long Tone DTMF Enable (Bit D5).** Normally set to 1.
	1	**Transportable Internal Ringer/Speaker Disable (Bit D4).** When set to 0, audio is routed to the accessory speaker of the transportable. When set to 1, audio is routed to the handset speaker. Normally set to 1.
	1	**Eight Hour Time-out Disable (Bit D3).** Normally set to 0.
	0	**Handset Test Mode Disable (Bit D2).** Enter 0.
	1	**Failed Page Indicator Disable (Bit D1).** When set to 1, the failed-call tone alert feature is disabled.
	1	**Word Sync Scan Disable (Bit D0).** Enter 1.

NOTE

If the second phone number bit is enabled, (step 11 C Option Byte bit 6), then steps 1- 6, 12, and 16 are repeated.
To store NAM data press the * key until the 'is displayed after step 19

Manual Test Mode

Introduction

Manual Test Mode software allows service personnel to monitor the telephone status on the display, and manually control tele-phone functions via the keypad.

Manual Test Mode operates at two levels: 1) Status Display level, which allows the phone to operate normally while providing status indications in the display; and 2) Servicing Level, which disables normal call-processing and allows commands to be entered through the keypad to manually control operation of the phone.

Entering Manual Test Mode

Manual Test Mode is entered by entering the following keypad sequence:

FCN 0 0 * * T E S T M O D E STO

Once this key sequence is completed the Status Display screen appears. Press and hold the # key for 2 seconds to enter in manual test mode.

Figure 19: "Connections for PCS Testing" on page 38 shows the recommended test setup.

Status Display Level

Status Display level is the power-up state in manual test mode. In this level of manual test mode the phone will place and receive calls as normal, but the display shows two lines of status information.

The display alternates between the channel number, RSSI status information, and primary status information:

- SAT frequency
- Carrier state
- Signaling tone state
- Power level
- Voice/data channel mode
- Audio states
- DVCC and BER measurements

The format of this status information is shown in Figure 17: "Test Mode Status Display (Analog Mode)" on page 35 and Figure 18: "Test Mode Status Display (Digital Mode)" on page 36.

When dialing a phone number, the status display ceases when the first digit of the phone number is entered. The telephone number is then displayed as it is entered. When the Snd, End, or Clr button is pressed, the status information display resumes. The phone remains in Status Display Mode if the # key is pressed momentarily.

Servicing Level

The Servicing Level of Manual Test Mode allows service personnel to manually control operation of a phone by entering commands through the telephone keypad. Parameters such as operating channel, output power level, muting, and data trans-mission can all be selected by entering the corresponding commands.

To enter the Servicing Level, press and hold the # button for at least 2 seconds while in Status Display level (power-up state of manual test mode.)

In the Servicing Level, automatic call processing functions are disabled, and the phone is instead controlled manually by keypad commands.

Table 3, "Test Commands For Manual Test Mode," on page 23 lists the commonly used manual test commands and the resulting display and telephone function for each command.

Figure 17. Test Mode Status Display (Analog Mode)

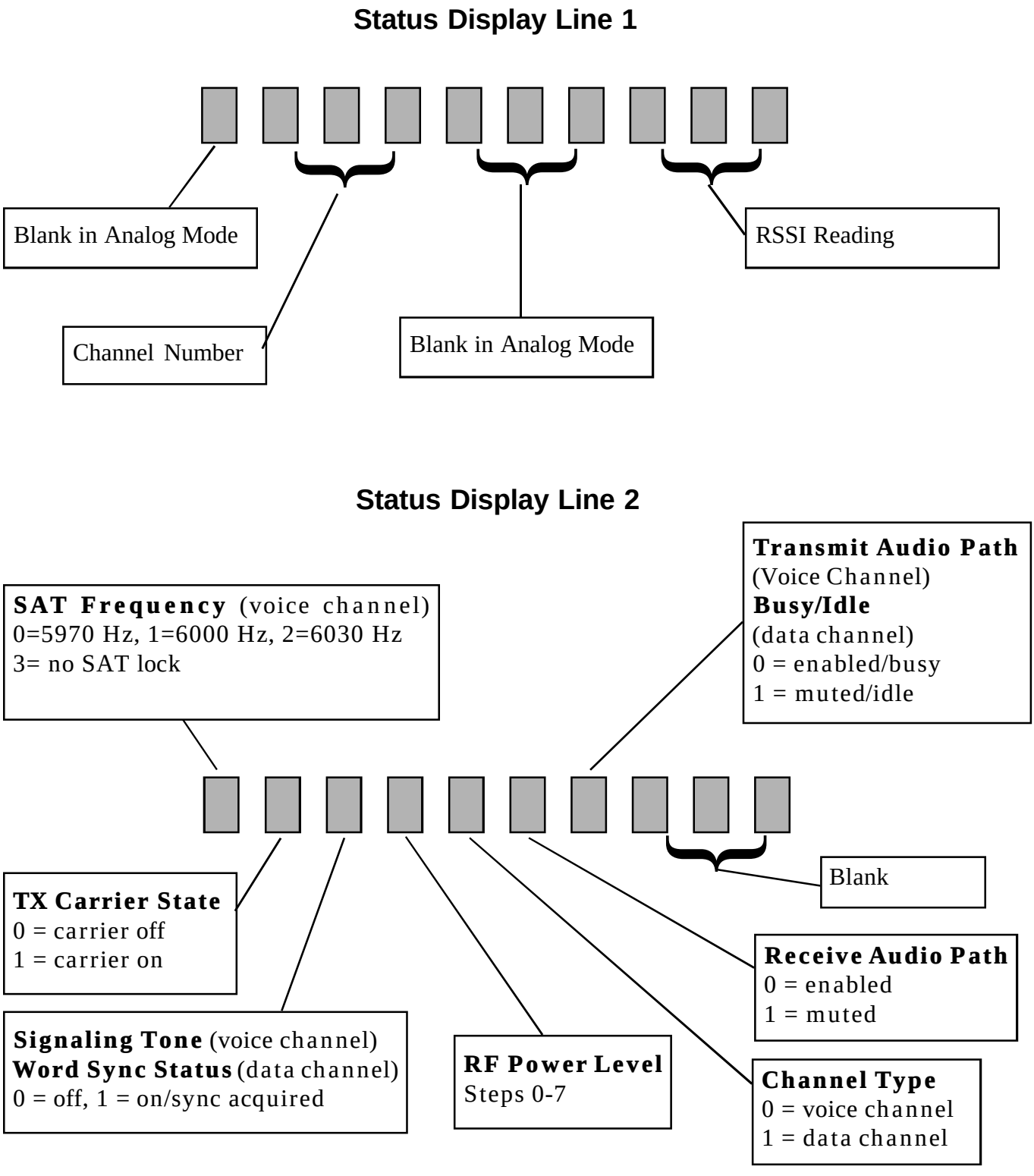
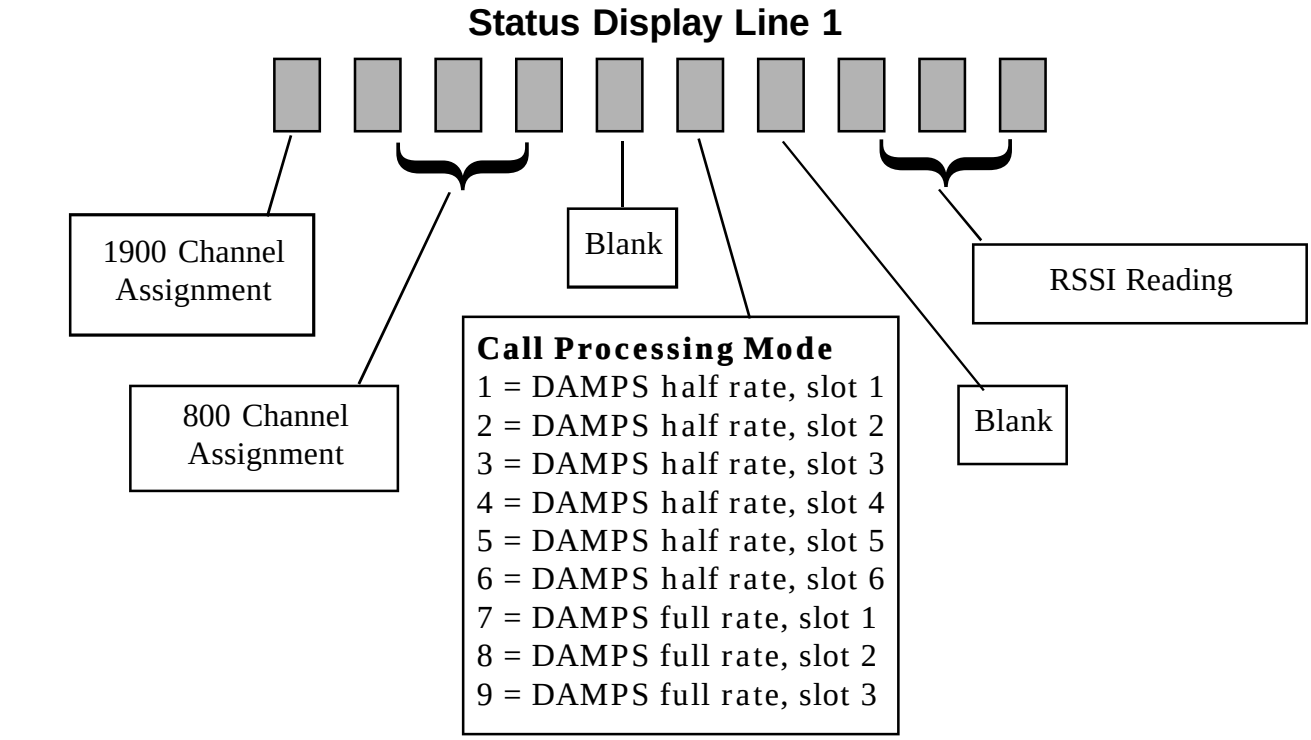
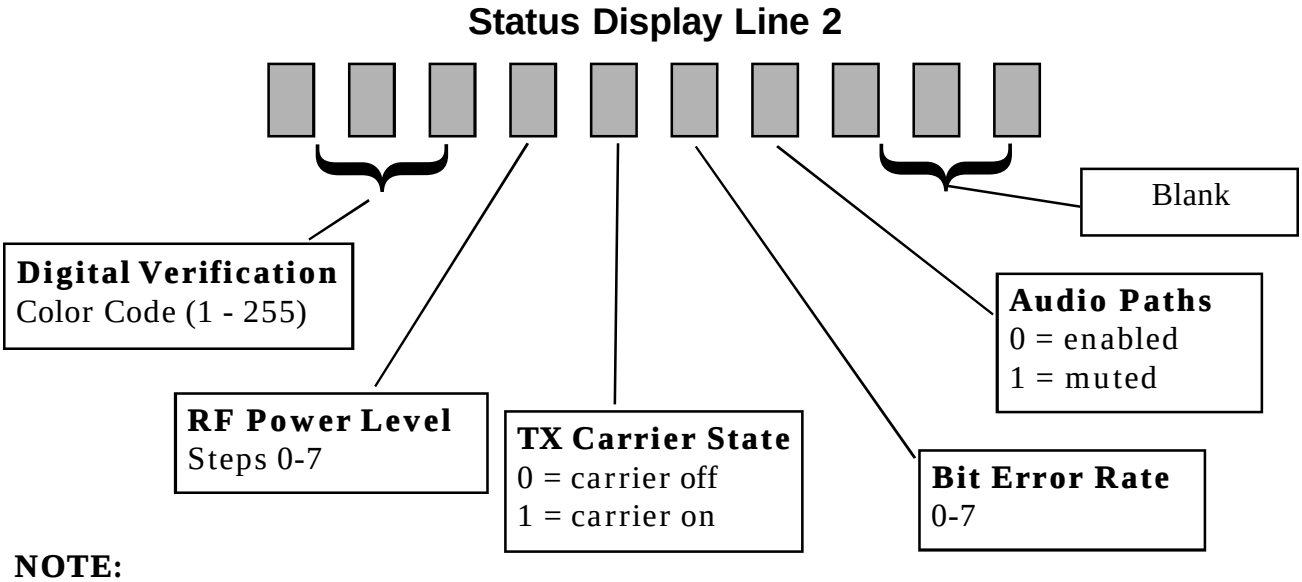


Figure 18. Test Mode Status Display (Digital


Status Display Line 1
1900 Channel Assignment
800 Channel Assignment
Blank
Call Processing Mode
1 = DAMPS half rate, slot 1
2 = DAMPS half rate, slot 2
3 = DAMPS half rate, slot 3
4 = DAMPS half rate, slot 4
5 = DAMPS half rate, slot 5
6 = DAMPS half rate, slot 6
7 = DAMPS full rate, slot 1
8 = DAMPS full rate, slot 2
9 = DAMPS full rate, slot 3
Blank
RSSI Reading



NOTE:
800MHz channels are displayed as three digits. Channel Numbers 1000-1023 are represented on the display as A00-A23.
1900MHz channels are displayed as four digits (0002 to 1998).

Test Procedures

Introduction

The phone allows keypad controlled testing of various analog and digital operating parameters.

This chapter includes the keypad button functions and recommended equipment setup to use when testing a phone.

Automatic Call-Processing Tests

Most communications analyzers can simulate a cell site in order to perform automatic call-processing tests. Automatic call processing tests can be performed while the phone is in its power-up state. However, it is useful to do the tests with the phone in Test Mode Status Display.

Refer to the communications analyzer's manual for details about performing call-processing tests. The following call-processing test sequence is recommended:

1. Inbound call, analog mode
2. Outbound call, analog mode
3. Analog-to-Analog channel handoff
4. Analog-to-Digital channel handoff
5. Inbound call, digital mode
6. Outbound call, digital mode
7. Digital-to-Digital channel handoff
8. Digital-to-Analog channel handoff

Handoffs should be performed between low, middle, and high frequency channels, such as, 991 (lowest frequency), 333 (middle frequency), and 799 (highest frequency). In digital mode slots 1 & 4, 2 & 5, and 3 & 6 should be verified.

Analog Test Measurements

- RX Sensitivity (SINAD)
- RX Audio Distortion
- TX Power Out
- TX Frequency Error
- TX Audio Distortion
- TX Maximum Deviation
- TX SAT Deviation
- TX ST Deviation

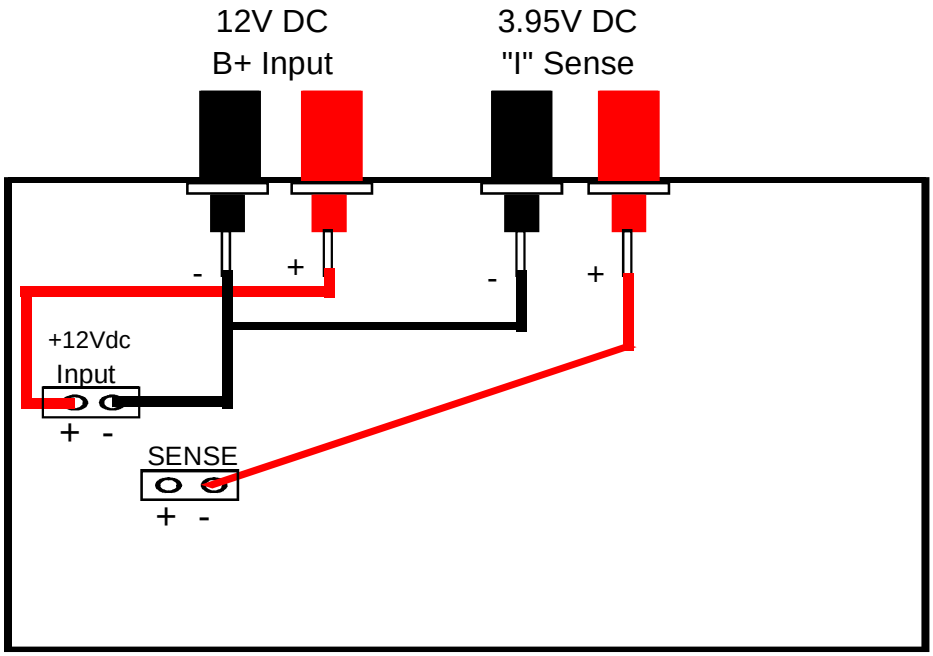
Digital Test Measurements

- Digital RX Sensitivity (BER)
- Digital Power Out
- TX Frequency Error
- Digital Modulation Stability (EVM)

The analog and digital parameters are stored in EPROM on the Transceiver Board. Each transceiver is shipped from the factory with these parameters already calibrated. However, if a board is repaired, these parameters should be measured and, if necessary, adjusted. Checking and adjusting calibration parameters is also useful as a troubleshooting/diagnostic tool to isolate defective assemblies.

MCEL 2000 Modifications

The diagram below shows the modification that the MCEL 2000 needs in order to properly supply the correct operating voltage to the cellular phone.



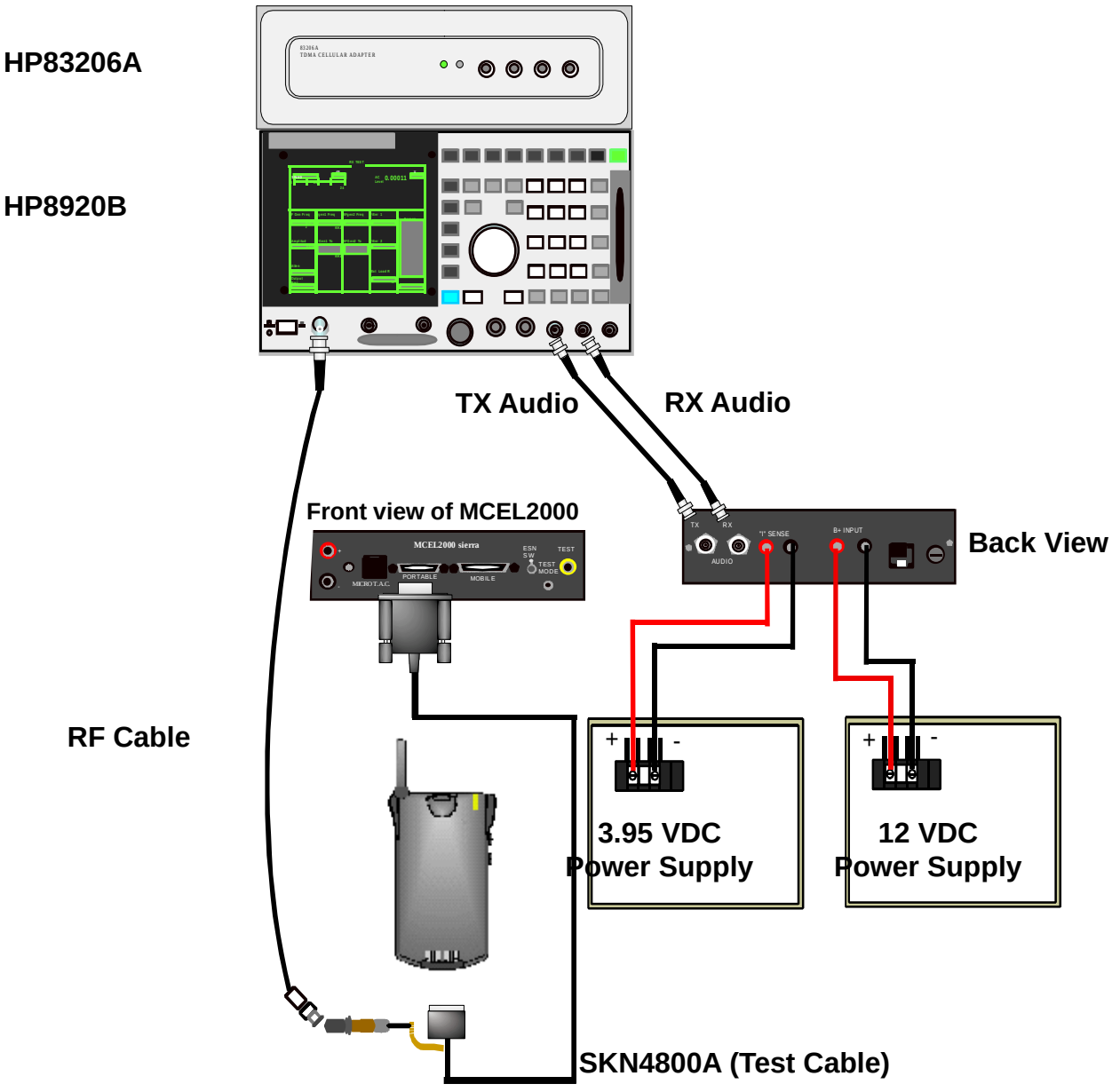
Test Connections

The diagram below shows the recommended connections for testing transceivers.

The MCEL2000 test interface and an RF adapter with a low loss RF cable is used to interface with the communications analyzer.

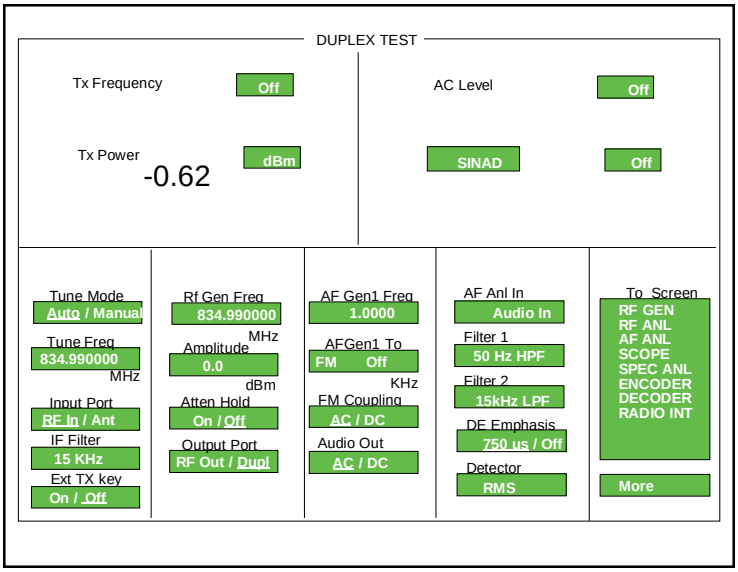
A variety of communications analyzers may be used. Refer to the analyzer manufacturer's user manual for proper setup before starting tests.

Figure 22. Connections for Testing



RF Cable Test

Figure 23. Duplex Test Screen



In order to properly measure and adjust the parameters of a telephone, it is important that you use RF cabling that has minimal loss. Therefore, it is important that you test the RF cable for proper loss. This can easily be done by using the DUPLEX TEST screen of your HP8920. To test the cable, set up the DUPLEX screen as shown above.

Action:

Take the cable under test and connect it from the RF in/out port to the Duplex Out port. At this point you will be getting some type of power reading for cable loss.

Good range: -.2 dBm through -.8 dBm

Bad cable: More than -.8 dBm

To test the RF cable for proper loss:

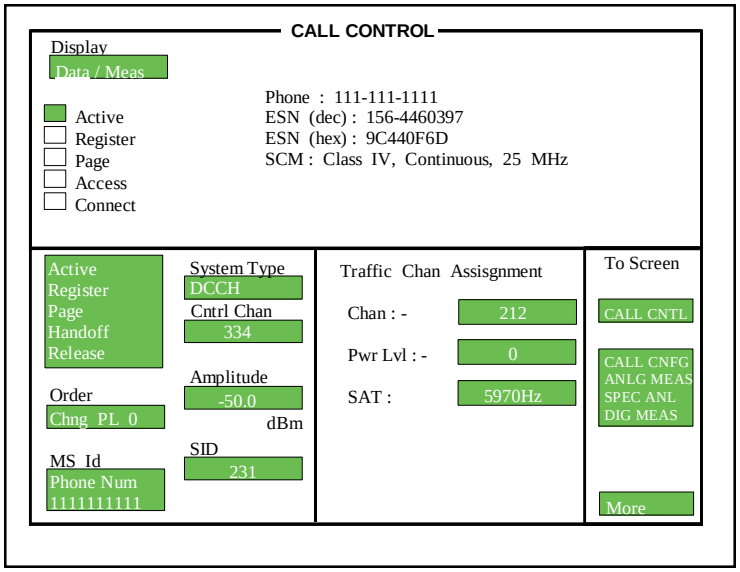
- **Tune Freq** should be set to TX frequency: 834.990000 MHz.
- **RF Gen Freq** should be set to same frequency (834.990000 MHz).
- **Tx Power** should be set to read in dBm, not Watts.

If the reading you are getting shows gain (positive number,) you may need to zero the power meter. This may happen on an HP8920 whose memory has just been cleared.

To zero the meter, press the **TX** button on the 8920 panel. Bring the cursor down to the field under **TX Pwr Zero** where it reads **Zero**. Tap the cursor on the Zero field and it will highlight for a moment as it zeroes the meter. Set up the screen as shown above, and test your cable.

Set up for Analog call

Figure 24. Call Control Screen



Select CALL CNTL from the To Screen

- Select System type: **AMPS**
- Zero the RF Power meter in the: **Call Config Screen**
- Set Amplitude to: **-50 dBm**
- Set SID: **Your phone's System ID**
- Select: **Active**
- **Voice Channel Assignment Type:**
- Chan: **212**
- Pwr Lvl: **4**
- SAT: **5970Hz**

Registration

1. Put the Test Set in Active state by selecting **Active** from the list on the left side of the screen.
2. Select **Data** from the **Data/Meas** field. This is the default mode.
3. Select **Register** from the list to register phone.
4. If the registration message has been received, the Test Set will display registration data in the upper half of the screen as shown in the sample screen above.

Page

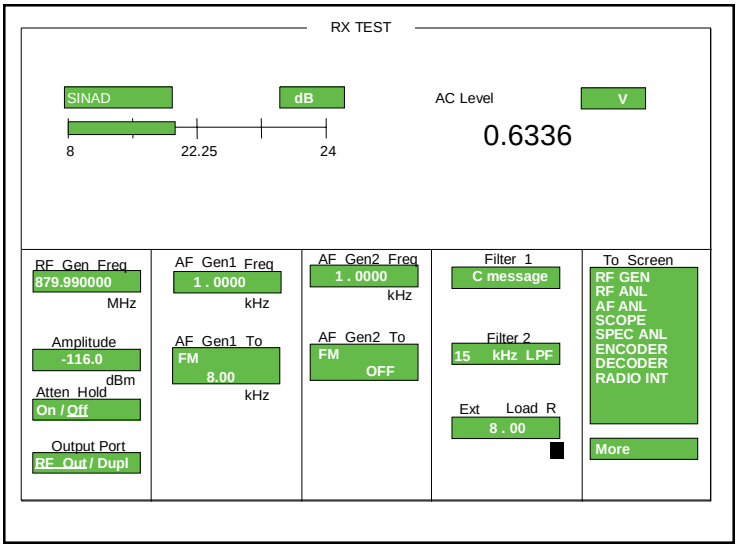
1 Select page from the list on the left side of the screen.
2 If the mobile responds, you will see the Access annunciator light briefly.
3 Answer the call by raising the flip or press SEND on the mobile to start the conversation.
4 The Connect annunciator lights. This is the Connect state.

Origination

1 Dial the desired phone number on the mobile station and press SEND.
2 The Access annunciator will light while the Test Set signals the mobile on the assigned voice channel.
3 The connect annunciator will light if the mobile properly signals the Test Set.

RX Sensitivity Test (SINAD)

Figure 25. RX Test Screen



Test Mode Commands:

11333#	Loads synthesizer to channel 333
08#	Unmute receive audio path
58#	Turn on compandor
474#	Set volume control to level 4
356#	Set RX audio path to Ext. Audio Path

Sinad measured on the communications analyzer must be more than 12dB.

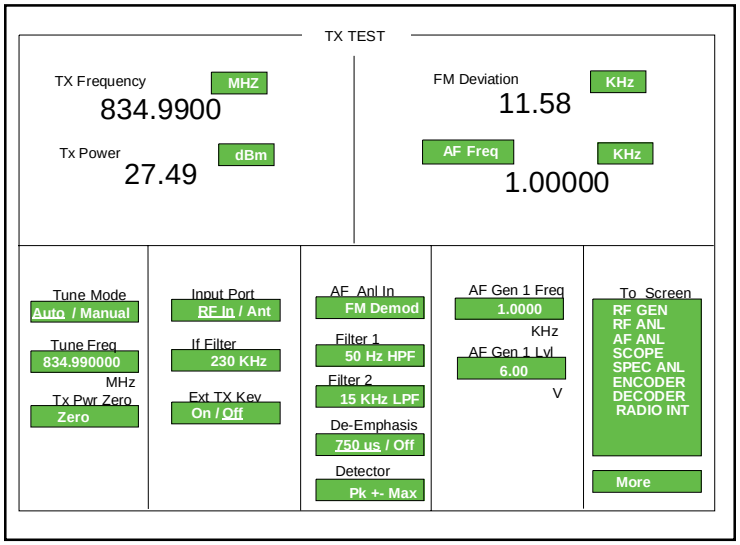
Duplex SINAD can be measured with the same setup by entering 122# and the 05# test command, which turns on the transmitter at power step 2. Narrow band SINAD can be measured by entering 571# and setting the FM Deviation to 3kHz. Refer to the RX troubleshooting section for radios not within the pass specifications.

Communications Analyzer Setup:

- Select **RX** button from the Screen Control panel
- Set **RX frequency** to **879.990 MHz**
- Set **Amplitude** to **-116 dBm**
- Set **AF gen1** to **1 kHz frequency** at **8 kHz deviation**, using **FM modulation** (PLEASE NOTE: this is for AMPS only; NAMPS uses much lower deviation)
- Set **AF Filter 1** set to **C message filtering**
- Set **AF Filter 2** to **15 kHz**

TX Power Out Test

Figure 26. TX Test Screen



Test Mode Commands:

11333#	Loads synthesizer to chan nel 333
12X#	Set power level to step X, where X is a power level from 1 to 7.
05#	Turns on transmit carrier

The TX Power Out specification for each portable power level is as follows:

Power Step 2	24dBm - 25dBm
Power Step 3	20.7dBm - 20.9dBm
Power Step 4	16.9dBm - 17.3dBm
Power Step 5	12.9dBm - 13.3dBm
Power Step 6	8.9dBm - 9.3dBm
Power Step 7	4.9dBm - 5.3dBm

Refer to the TX troubleshooting section for radios not within the pass specifications.

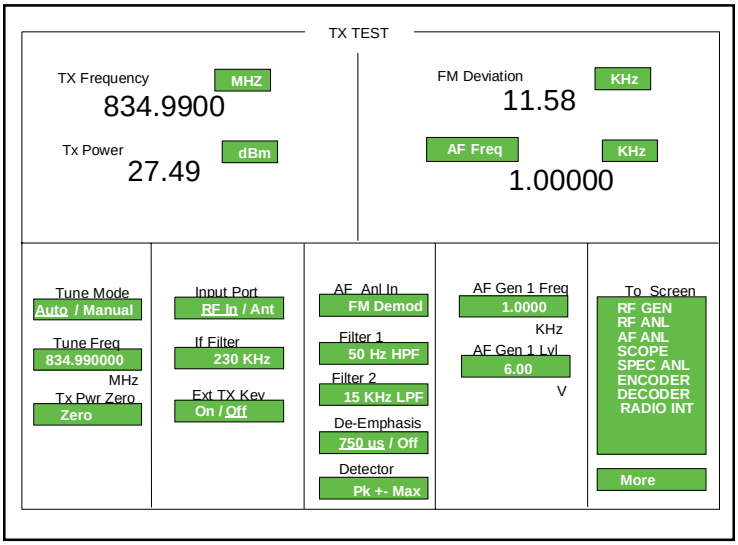
Note: When taking measurements, remember to compensate for cable loss.

Communications Analyzer Setup:

- **Select** TX **button from the Screen Control panel**
- **PWR** is measured in **dBm**
- Set **Frequency Measurement** to **auto or manual** (display will show TX Freq. Error)
- Set **TX frequency** to **834.990 MHz**
- Set **IF filter** to **230 kHz**
- Set **AF Filter 1** to **50 Hz**
- Set **AF Filter 2** to **15 kHz**
- Set **AF gen1** for **1 kHz frequency** at **6V level** (output will go to the **audio** port)

TX Frequency Error Test

Figure 27. TX Test Screen



Test Mode Commands:

11333#	Loads synthesizer to channel 333
122#	Set power level to step 2
05#	Turn on transmit carrier

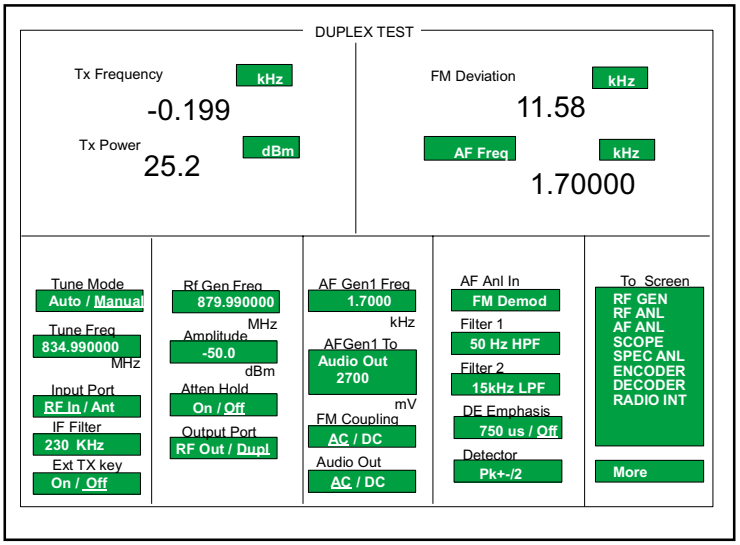
The frequency error measured on the communications analyzer must be less than ± 0.5 ppm.

Communications Analyzer Setup:

- **Select TX button from the Screen Control panel**
- **PWR** is measured in **dBm**
- Set **Frequency Measurement** to **auto or manual** (display will show TX Freq. Error)
- Set **TX frequency** to **834.990 MHz**
- Set **IF filter** to **230 kHz**
- Set **AF Filter 1** to **50 Hz**
- Set **AF Filter 2** to **15 kHz**
- Set **AF gen1** for **1 kHz frequency** at **6V level** (output will go to the **audio** port)

TX Maximum Deviation Test

Figure 28. TX Test Screen



Test Mode Commands:

11333#	Load synthesizer to channel 333
122#	Set power level to power step 2
05#	Turn on transmit carrier
356#	Select External TX Audio path
10#	Unmute TX Audio path
58#	Turn on compandor

View FM Deviation for reading.

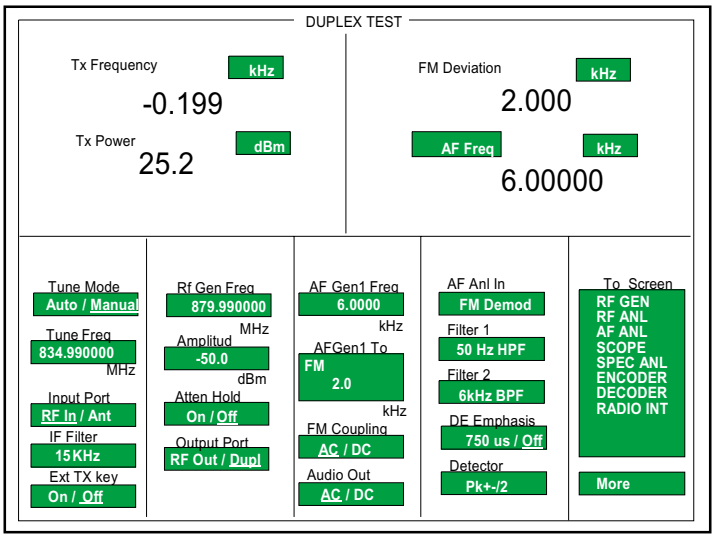
TX Maximum Deviation Pass Specifications: 11.1 kHz - 11.99 kHz.

Communications Analyzer Setup:

- Select **DUPLEX** button from the Screen Control panel
- **PWR** is measured in **dBm**
- Set **Frequency Measurement** to **auto or manual** (display will show TX Freq. Error)
- Set **Tune freq** to **834.990000 MHz**
- Set **Input Port** to **RF In**
- Set **IF filter** to **230 kHz**
- Set **Ext TX Key** to **Off**
- Set **RF Gen Freq** to **879.990000 MHz**
- Set **Amplitude** to **-50 dBm**
- Set **Atten Hold** to **Off**
- Set **Output Port** to **Dupl**
- Set **AF Gen1 Freq** to **1.7000 kHz**
- Set **AF Gen1 To** to **Audio Out** and **2700 mV**
- Set **FM Coupling** to **AC**
- Set **Audio Out** to **AC**
- Set **AF Anl In** to **FM Demod**
- Set **Filter 1** to **50 Hz HPF**
- Set **Filter 2** to **15 kHz LPF**
- Set **DE Emphasis** to **Off**
- Set **Detector** to **Pk+-/2**

TX SAT Deviation Test

Figure 29. Call Control Screen



Test Mode Commands:

11333#	Load synthesizer to channel 333
122#	Set power level to power step 2
05#	Turn on transmit carrier
251#	Enable 6000 Hz SAT tone

View FM Deviation for the reading.

The transponded SAT FM deviation specifications: 1.95 kHz - 2.2 kHz.

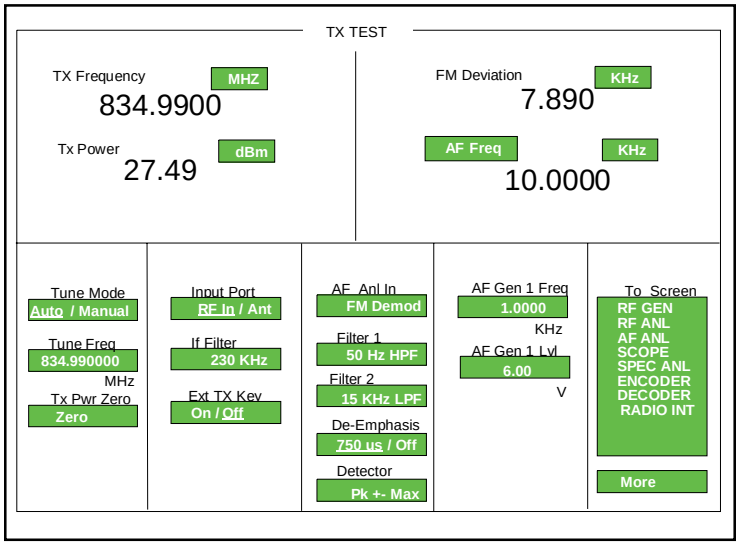
The demodulated signal on the communications analyzer should have an audio frequency of 6000 Hz.

Communications Analyzer Setup:

- Select **DUPLEX** button from the Screen Control panel
- **PWR** is measured in **dBm**
- Set **Frequency Measurement** to **auto or manual** (display will show TX Freq. Error)
- Set **Tune freq** to **834.990000 MHz**
- Set **Input Port** to **RF In**
- Set **IF filter** to **15 kHz**
- Set **Ext TX Key** to **Off**
- Set **RF Gen Freq** to **879.990000 MHz**
- Set **Amplitude** to **-50 dBm**
- Set **Atten Hold** to **Off**
- Set **Output Port** to **Dupl**
- Set **AF Gen1 Freq** to **6.0000 kHz**
- Set **AF Gen1 To** to **FM** and **2.0 kHz**
- Set **FM Coupling** to **AC**
- Set **Audio Out** to **AC**
- Set **AF Anl In** to **FM Demod**
- Set **Filter 1** to **50 Hz HPF**
- Set **Filter 2** to **6 kHz BPF**
- Set **DE Emphasis** to **Off**
- Set **Detector** to **Pk+-/2**

TX ST Deviation Test

Figure 30. TX Test Screen



Test Mode Commands:

11333#	Load synthesizer to channel 333
122#	Set power level to power step 2
05#	Turn on transmit carrier
14#	Enable signaling tone

View FM Deviation for reading.

The peak ST deviation measured on the communications analyzer should be between 7.2 kHz - 8.6 kHz.

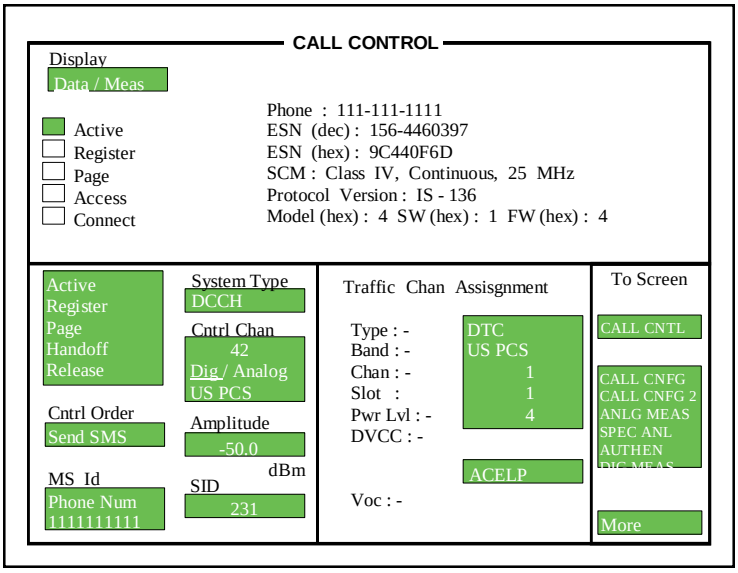
The demodulated signal on the communications analyzer should have an audio frequency of 10 kHz.

Communications Analyzer Setup:

- Select **TX** button from the Screen Control panel
- **PWR** is measured in **dBm**
- Set **Frequency Measurement** to **auto or manual** (display will show TX Freq. Error)
- Set **TX frequency** to **834.990 MHz**
- Set **IF filter** to **230 kHz**
- Set **AF Filter 1** to **50 Hz**
- Set **AF Filter 2** to **15 kHz**
- Set **AF gen1** for **1 kHz frequency** at **6V level** (output will go to the **audio** port)

Set up for TDMA call

Figure 35. Call Control Screen



Call Process

The following 4 steps need to be performed prior to beginning registration test:

1. Enter Test Mode using **FNC 0, 0, *, *, T, E, S, T, M, O, D, E, STO.**
2. Perform a 51# command in Test Mode to clear the Historic List. Turn off the telephone.
3. Connect the RF connector to the radio and power on.

Registration

1. Put the Test Set in Active state by selecting **Active** from the list on the left side of the screen.
2. Select **Data** from the **Data/Meas** field. This is the default mode.
3. Select **Register** from the list to register phone.
4. If the registration message has been received, the Test Set will display registration data in the upper half of the screen as shown in the sample screen above.

Select CALL CNTL from the To Screen

- Select System type: **DCCH**
- Zero the RF Power meter in the: **Call Config Screen**
- Set Amplitude to: **-50 dBm**
- Set SID: **Your phone's System ID**
- Select: **Active**
- **Traffic Channel Assignment Type:**
- Choose **DTC** to set up a Digital Traffic channel
- Type: **DTC**
- Chan: **1**
- Slot: **1**
- Pwr Lvl: **4**
- DVCC: **1**

Page

1 Select page from the list on the left side of the screen.

2 If the mobile responds, you will see the Access annunciator light briefly.

3 Answer the call by raising the flip or press SEND on the mobile to start the conversation.

4 The Connect annunciator lights. This is the Connect state. Data to be displayed is shown above.

Origination

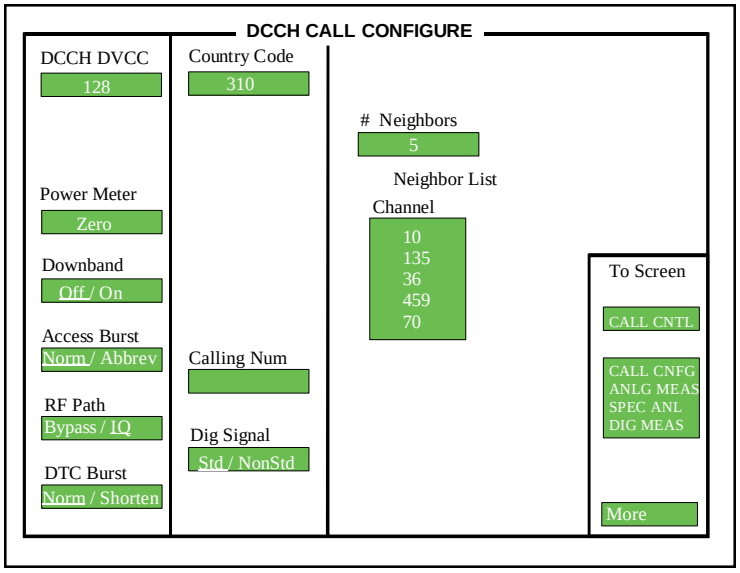
1 Dial the desired phone number on the mobile station and press SEND.

2 The Access annunciator will light while the Test Set signals the mobile on the assigned voice channel.

3 The connect annunciator will light if the mobile properly signals the Test Set.

MAHO Measurements

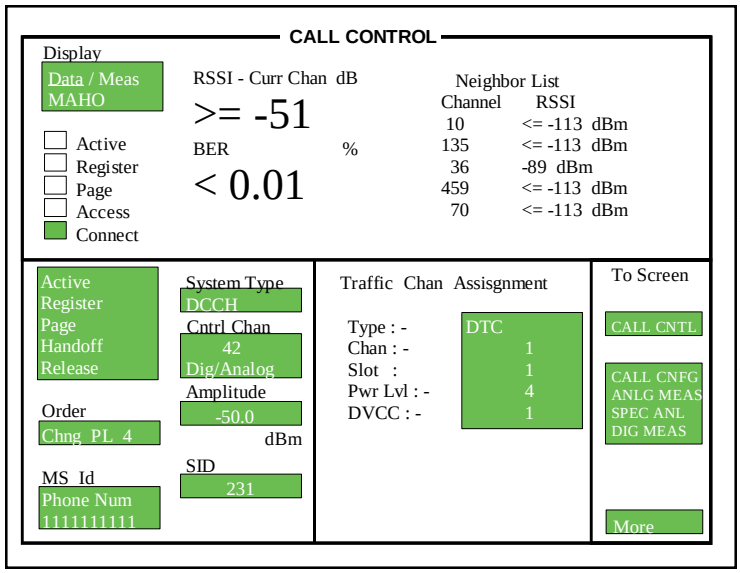
Figure 36. DCCH Call Configure Screen



Setting up the MAHO measurement

1 Select **CALL CNFG** from the CALL CONTROL's **To Screen.**
2 Set the number of neighbors (up to 6) with the field # Neighbors.
3 **Neighbor List Channel** fields ap pear below the **# Neighbors** field.
4 Set the channel number of each neigh bor channel.

Figure 37. Call Control Screen



Measuring MAHO

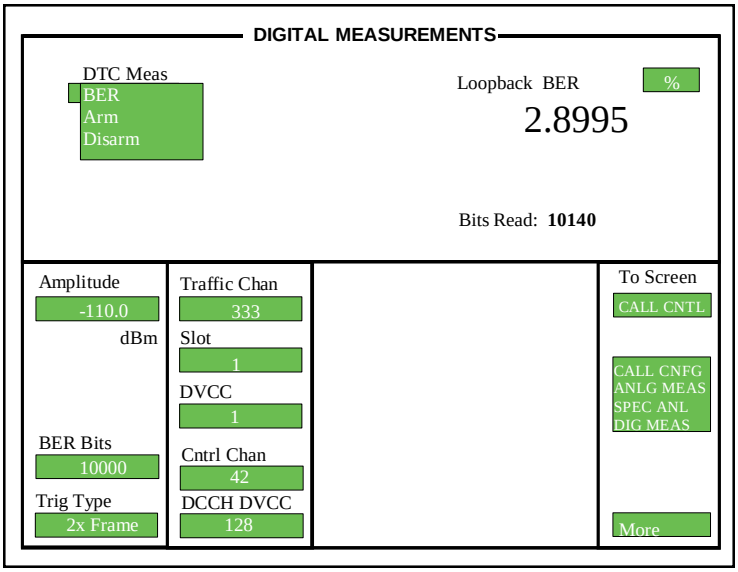
1 From **CALL CONTROL** screen, set up a call (Test Set must be in Connect mode).
2 Select **Meas** from the **Data / Meas** field.
3 Select the field that has appeared be low **Data / Meas.**
4 Select **MAHO** from the list of choices.
5 The **RSSI** and **BER** of the current channel are reported, as well as the **RSSI** of the designated neighbor chan nels.

MAHO (Mobile Assisted HandOff) is actually a measurement, not a handoff. The reported results are used by a base station to select the channel for the handoff.

The mobile performs the measurements, and them reports the results back to the base station. The mobile measures the **RSSI** of neighboring channels, as instructed by the base station. It also measures and reports the **RSSI** and **BER** of the current channel.

BER Measurements

Figure 37. Digital Measurements Screen



Test Mode Commands:

1 Enter 576# (Loopback mode)
2 11333# (Loads Synthesizer Channel)
3 Display prompt "Y" (enter desired time slot, for this test enter 1)
4 Set power level to step 2 (122#)
5 Turn on transmitt carrier (05#)

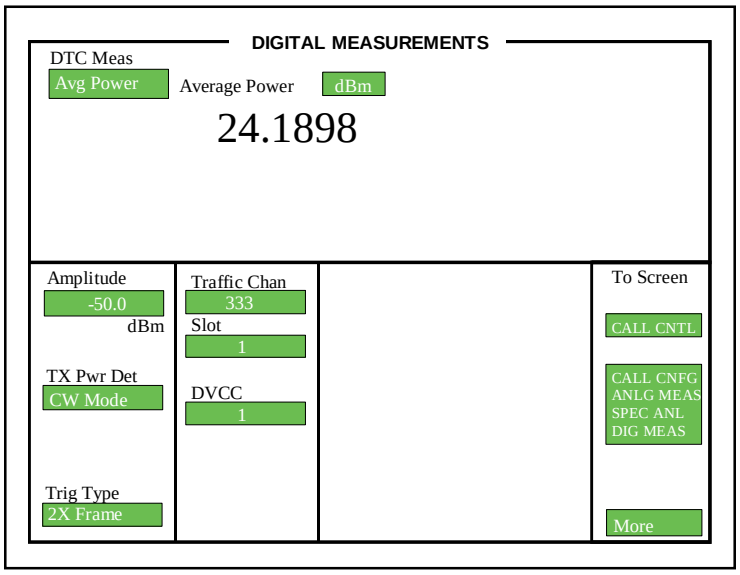
The BER measured on the communications analyzer must be less than or equal to **3%**.

BER Measurement Procedure

1 Make sure the Test Set is in Active mode.
2 Select **DIG MEAS** from the **To Screen** menu.
3 Select the **DTC Meas** field to display a list of available tests.
4 Select **BER** from the list.
5 Enter the number of bits to be measured in the **BER Bits** field. (Note: the number of bits actually read will be calculated in whole frames.)
6 **Amplitude** should be set to -110 dBm.
7 **Traffic Chan** to 333.
8 **Slot** to 1.
9 **DVCC** to 1.
10 **Cntrl Chan** to 42.
11 **DCCH DVCC** to 128.
12 Put the mobile into test mode and enter the proper test commands for **BER** reading.
13 Select **ARM**.
14 After the actual number of bits has been transmitted and received, the **BER** should be displayed.

TX Power Measurements

Figure 38. Digital Measurements Screen



Digital TX Power Out Test Procedure

1 Make sure the Test Set is in Active mode.
2 Select **DIG MEAS** from the **To Screen**.
3 Select the **DTC Meas** field. This shows the **To Screen** with a list of available tests.
4 Select **AVG Power.**
5 **Traffic Chan** should be set to 333.
6 Put the mobile into test mode.
7 Make Digital TX Power Out measure ments.

Test Mode Commands:

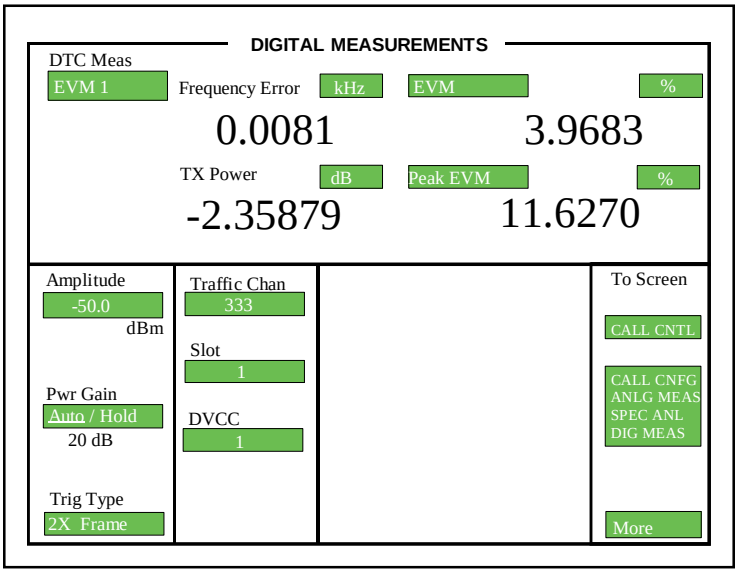
1 Enter 575# (Digital signaling mode)
2 11333# (Loads synthesizer Channel)
3 Display prompt “Y” (enter time slot)
4 Set power level to step 2 (122#)
5 Turn on transmitt carrier (05#)

Digital TX power step 2 specifications is:
25.0 dBm - 26.0 dBm minus cable loss.

You can also use Digital Call processing to make these measurements.

TX Frequency Error Measurements

Figure 39. Digital Measurements Screen



TX Frequency Error Measurement Test

1 Make sure the Test Set is in Active mode.
2 Select **DIG MEAS** from the **To Screen**.
3 Select the **DTC Meas** field. This shows the **To Screen** with a list of available tests.
4 Select **EVM 1**.
5 **Traffic Chan** should be set to 333.
6 Put the mobile into test mode.
7 Frequency error is displayed.

Test Mode Commands:

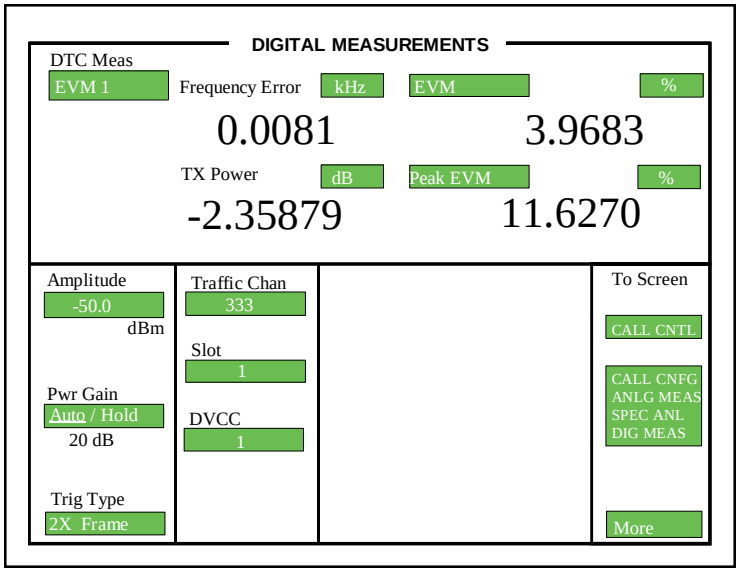
1 Enter 575# (Digital signaling mode)
2 11333# (Loads synthesizer Channel)
3 Display prompt “Y” (enter time slot)
4 Set power level to step 2 (122#)
5 Turn on transmitt carrier (05#)

The frequency error measured on the communications analyzer must be **±200Hz**.

You can also use Digital Call processing to make these measurements.

EVM Measurements

Figure 40. Digital Measurements Screen



TX Frequency Error Measurement Test

1 Make sure the Test Set is in Active mode.
2 Select **DIG MEAS** from the **To Screen**.
3 Select the **DTC Meas** field. This shows the **To Screen** with a list of available tests.
4 Select **EVM 1**. **EVM 10** can also be selected, it measures a 10 burst aver age.
5 **Traffic Chan** should be set to 333.
6 Put the mobile into test mode.
7 EVM is displayed.

Test Mode Commands:

1 Enter 575# (Digital signaling mode)
2 11333# (Loads synthesizer Channel)
3 Display prompt “Y” (enter time slot)
4 Set power level to step 2 (122#)
5 Turn on transmitt carrier (05#)

The 10 burst average EVM measured should be less than or equal to **10%**.

You can also use Digital Call processing to make these measurements.

Disassembly

Introduction

To perform most repairs, the unit must be disassembled in order to gain access to the various internal components. Reasonable care should be taken in order to avoid damaging or stressing the housing and internal components. Motorola recommends the use of a properly grounded high impedance conductive wrist strap while performing any of these procedures.

CAUTION

Many of the integrated circuit devices used in this equipment are vulnerable to damage from static charges. An anti-static wrist band, connected to an anti-static (conductive) work surface, must be worn during all phases of disassembly, repair, and reassembly.

Recommended Tools

The following tools are recommended for use during the disassembly and reassembly of the StarTAC.

- Anti-Static Mat Kit (RPX-4307A); includes:
  - — Anti-Static Mat 66-80387A959
  - — Ground Cord 66-80387A989
  - — Wrist Band 42-80385A59
- Plastic Prying Tool SLN7223A
- Antenna Tool SYN5179A
- Tweezers
- Disassembly Fixture 8185677C02

Transceiver Disassembly

The preferred method for transceiver disassembly is using the disassembly fixture.

Refer to page 17 for step by step instructions on using the disassembly fixture.

NOTE

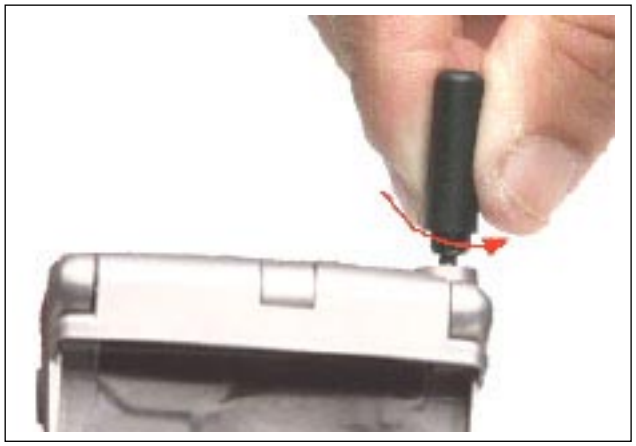
Service personnel should be familiar with all of the following information before attempting unit disassembly.

Antenna Removal

Step 1. Turn off the telephone.

Step 2. Press down on the battery's tab and remove the battery from the housing.

Step 3. Using the antenna removal tool, turn the antenna counterclockwise until the antenna is free from the phone housing. For the stubby antenna you can use your fingers to turn the antenna counterclockwise until the antenna is free from the phone housing.



Opening Housing

Step 1. With flat surface of tool facing up, insert housing opener at a 45° angle. Make sure you can see top of tool in seam.

Step 2. Press and push corner outwards with left thumb while right hand twists phone.

Step 3. After phone has started to open, lift at antenna collar to release entire side.

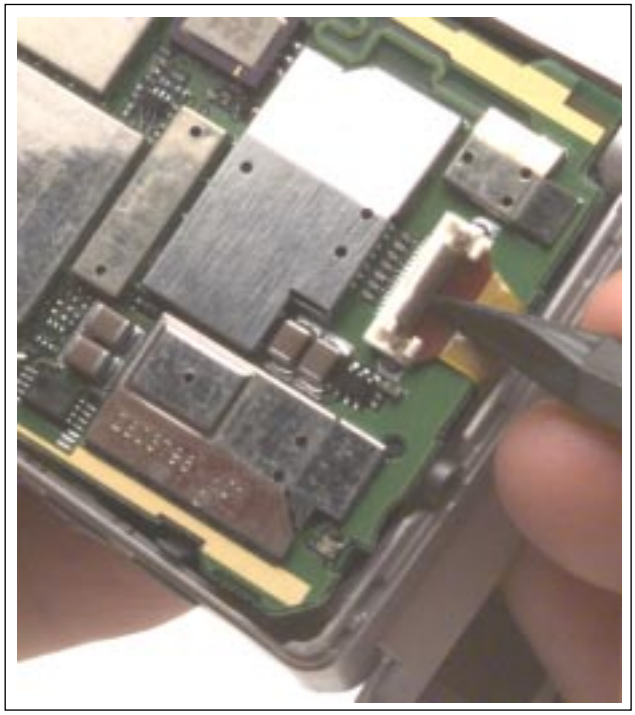
Step 4. Using the small plastic prying tool, slide under housing all the way to corner and lift housing off corner.

Step 5. With flat surface of tool facing up, insert housing opener at a 45° angle. Make sure you can see top of tool in seam.

Step 6. Grasp the backhousing and pull the backhousing off going straight across phone.

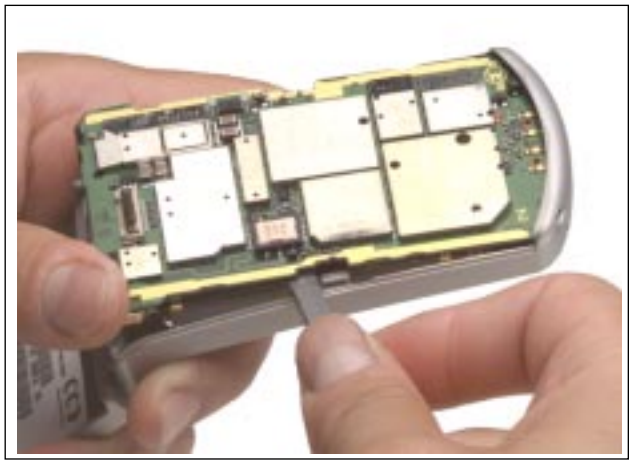
Board Removal

Step 1. Open the flex connector and pull out the flex.



Step 2. Using the plastic prying tool, pry the side tabs away from the assembly to allow it to be easily removed.

Step 3. Starting at the top of the board, using your thumb and index finger, lift the board assembly out of the front housing



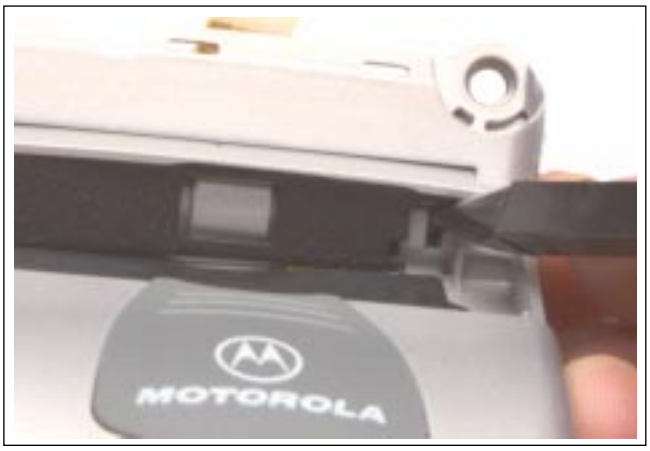
Step 4. Using your index finger, lift and seperate the display board and audio-logic board assembly from the transceiver board.

Flip Removal

Step 1. Using the pointed end of the plastic disassembly tool, pry off the left side of the cover.

Step 2. Using the pointed end of the plastic prying tool, insert it on the right side of the locking tab.

While pushing inward, force the locking tab to the left to release.



Step 3. Once the tab is released, peel off and slide the cover away from the flip.

Step 4. Remove the flip by pulling up on the hinge pin side and out on the other side.

The hinge shaft may come loose from the flip.

Speaker / Vibrator Removal

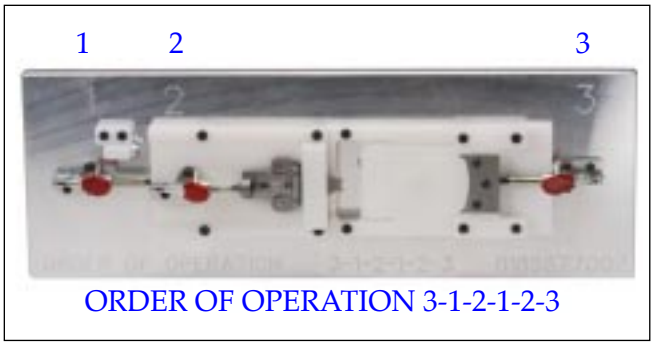
Step 1. Rest flip housing on a flat surface. Slip the tweezers between front housing and battery contacts.

Pry up to unsnap front housing and battery contacts.

The speaker, vibrator, and flex should be exposed.

Opening Housing using fixture

Using the fixture (8185677G02) to the right and following the order of operation directions that is etched on the fixture itself, will allow you to open the StarTAC radio, causing minimal damage to the housing.

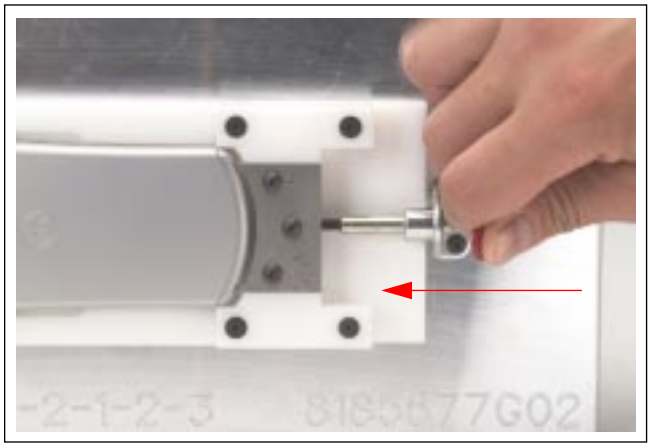


ORDER OF OPERATION 3-1-2-1-2-3

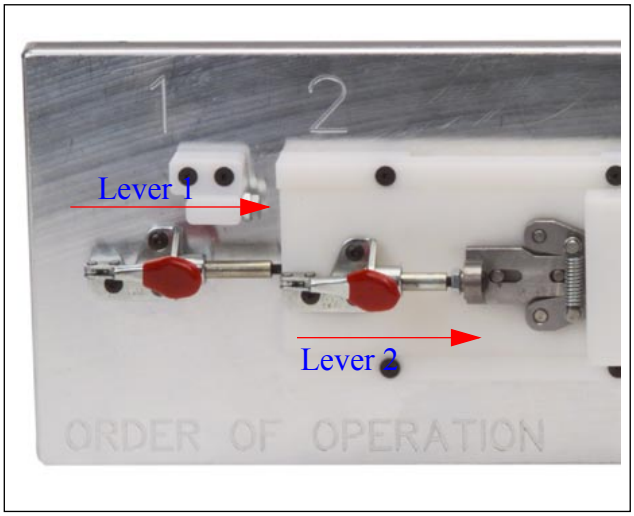
Following is the step by step procedure on how to use this fixture

Step 1. Open the flip of the StarTAC radio and insert it into the fixture (8185677G02) as shown to the right.

Step 2. Connect the two tooling pins into the radio's opening ports and lock them by engaging lever 3 as shown to the right.

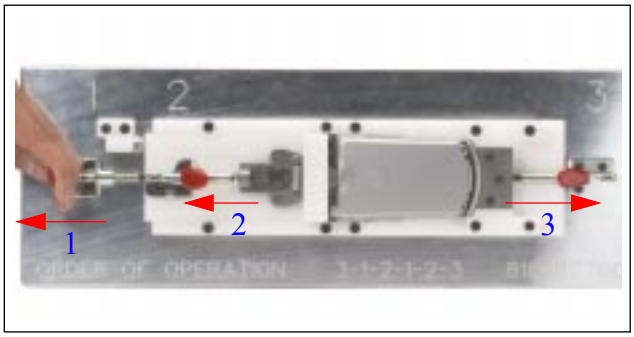


Step 3. Engage lever 1 followed by lever 2 as shown to the right.



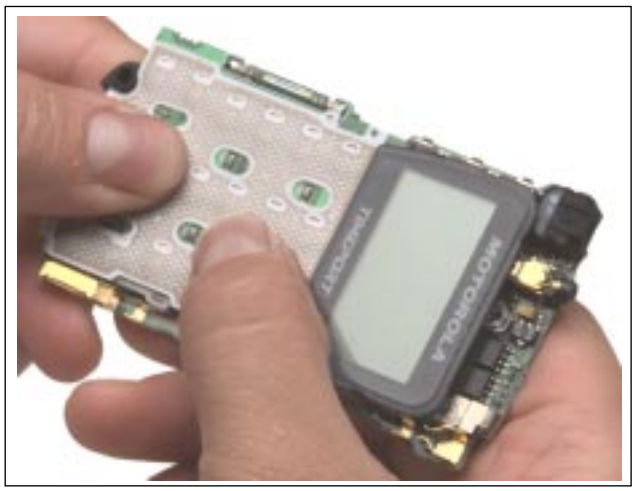
Step 4. Disengage lever 1 to detach rear housing, followed by lever 2 then lever 3. Remove the radio from fixture and remove the rear housing.

Go to the Board Removal section of this manual located on page 67 for instruction on how to remove the board from its housing.

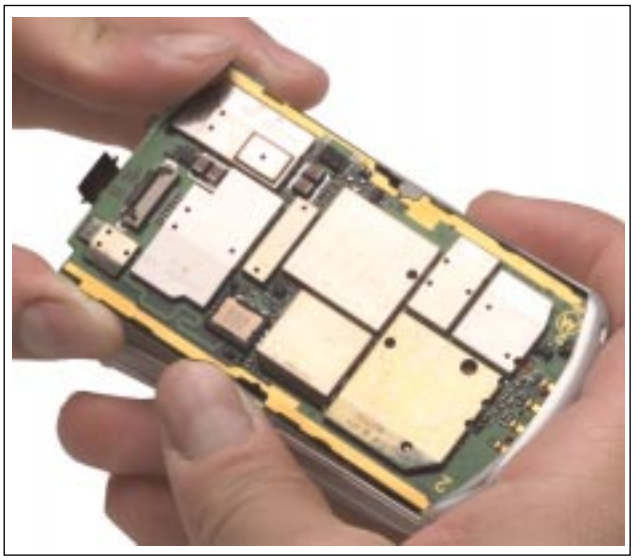


Board Assembly

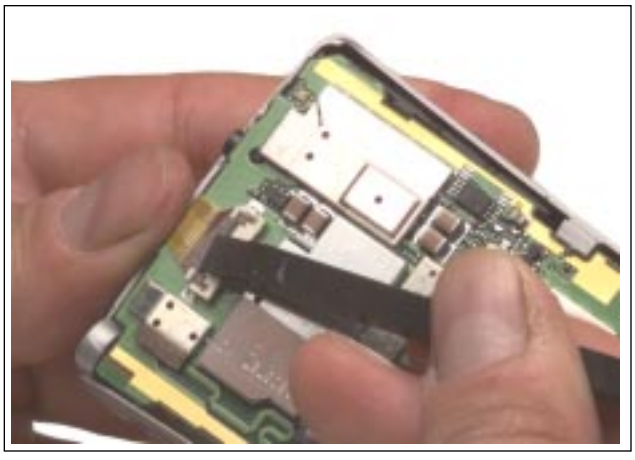
Step 1. Place the display and audio logic board on top of RF board and press firmly making sure your Inter connector is properly connected.



Step 2. To place the board back into the housing, pry the side tabs away from the board assembly to allow it to be re-inserted.



Step 3. Insert the flex into connector and close flex connector.



Closing housing

Step 1. Place backhousing on phone making sure side snaps clip the backhousing and push forward snapping everything back in place.

Step 2. Insert antenna and with the antenna removal tool, turn the antenna clockwise until it locks into place. Be careful not to apply too much pressure, as that would damage the antenna. For the stubby antenna you can use your fingers to turn the antenna clockwise until it locks into place.

Parts List

Introduction

Motorola maintains a parts office staffed to process parts orders, identify part numbers, and otherwise assist in the maintenance and repair of Motorola Cellular products. Orders for all parts listed in this document should be directed to the following Motorola International Logistics Department:

Accessories and Aftermarket (AAD)
Schaumburg, IL, USA

Domestic
Customer Service: 1-800-422-4210
Hours: 7am - 7pm US Central Time

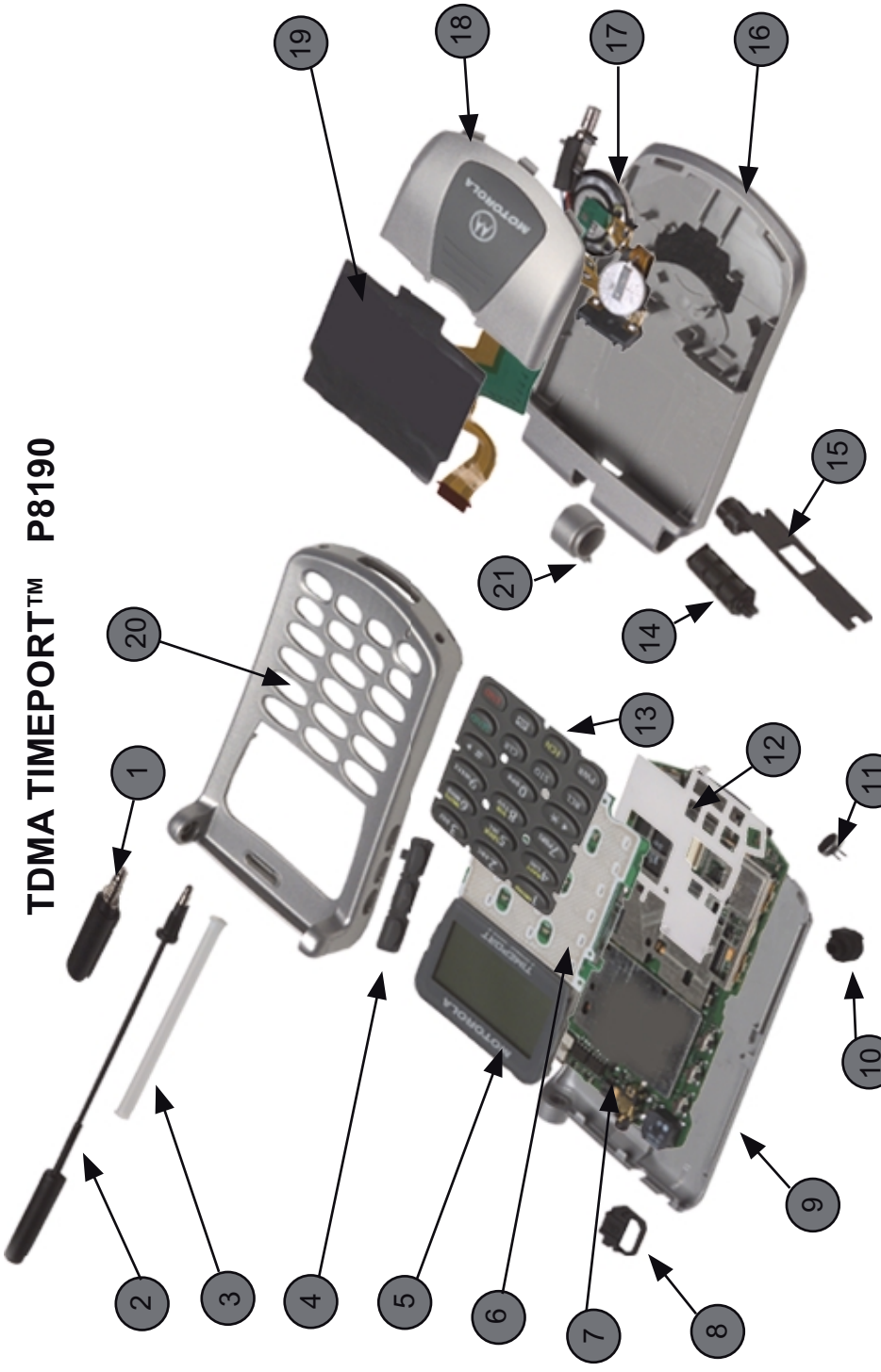
International
Customer Service: 1-847-538-8023
Hours: 8am - 6:30pm US Central Time

When ordering replacement parts or equipment information, the complete identification number should be included. This applies to all components, kits, and chassis. If the component part number is not known, the order should include the number of the chassis or kit of which it is a part, and sufficient description of the desired component to identify it.

Mechanical Explosion

The Mechanical explosion contains a table of mechanical part numbers that may change after publication of this manual. For an updated list of part numbers contact an AAD representative at the numbers listed above.

TDMA TIMEPORT™ P8190



1	ANTENNA-DUAL	8585965H01	8	ALERT GROMMET	0585701K01	15	R.SHAFT W/COVER 4709038K02 *
2	ANTENNA-800MHZ	0104976Z02	9	REAR HSG.	0185798K01	16	FLIP HSG. *
3	ANTENNA TUBE.	0187367K03	10	MIC. GROMMET	0585702K01	17	FLEX ASSY. *
4	VOL.GROMMET	N/A	11	MIC.	5009135L07	18	REAR FLIP COVER *
5	LENS	0185697K01	12	SPACER	0785967J01	19	FLEX LABEL 5485942H01 *
6	KYBD W/DISPLAY	0109133U08	13	KEYPAD	3885696K18	20	FRT. HSG. 0185693K01
7	RF BRD.	N/A	14	SPRING ASSY.	5509242E01	21	FLEX BARREL *

* PARTS ARE USED IN ASSY.-0185815K01

Reference Designator	Part Number
A2	39-85833H01
C10	21-13743N40
C100	21-13743N24
C1000	21-13743M24
C1001	21-13741F49
C1002	21-13743E20
C1003	21-13743E20
C1004	21-13743M24
C1005	21-13743M24
C1006	21-13743M24
C1008	21-13743N40
C1009	21-13743N40
C101	21-13743N19
C1010	21-13743N40
C1011	21-13743N40
C1012	21-13743E20
C1013	21-13743N40
C1014	21-13743N40
C1015	21-13743N40
C1016	21-13743N40
C1017	21-13743N40
C1018	21-13743N40
C1019	21-13743N40
C102	21-13743E20
C1020	21-13743N40
C1021	21-13928P04
C1022	21-13743M24
C1023	21-13743M24
C103	21-13743E20
C104	21-13743E20
C105	21-13743E20
C106	21-13743A23
C107	21-13743L41
C1070	21-13743N40
C1071	21-13743N40
C1072	21-13743N40
C1073	21-13743N40
C1074	21-13743N50
C1075	21-13743N40
C1076	21-13743N40
C108	21-13743L17
C109	21-13743A23
C1093	21-13743M24
C11	21-13743N20
C110	21-13743E20
C111	21-13743L17
C112	21-13743L41
C113	21-13743L05

Reference Designator	Part Number
C114	21-13743L17
C115	21-13743L41
C1200	21-13928P04
C121	21-13743N30
C122	21-13743N30
C123	21-13743L01
C124	21-13743E07
C125	21-13743L01
C126	21-13743L05
C127	21-13743L11
C128	21-13743L17
C129	21-13741A59
C131	21-13741F39
C132	21-13743E20
C133	21-13743N50
C134	21-13743L41
C135	21-13743N26
C14	21-13743N34
C15	21-13743L17
C150	21-13743L41
C1501	21-13928G01
C1502	21-13743N24
C1503	21-13743N24
C1504	21-13743M24
C1505	23-11049A62
C1506	23-11049A59
C1507	21-13743E20
C1508	23-11049A59
C1509	23-11049A62
C151	21-13743N40
C1510	21-13743N40
C1511	21-13743N40
C1513	21-13743L05
C1514	21-13743N50
C1515	21-13743E20
C1516	21-13928N01
C1518	23-11049A89
C1519	21-13743L01
C152	21-13743N35
C1520	21-13743L01
C1521	21-13743N40
C1522	21-13743N40
C1523	21-13743N40
C1528	21-13743N40
C153	21-13743N37
C1530	23-11049A59
C1531	23-11049A59
C1532	21-13743N40

Reference Designator	Part Number
C1533	21-13928N01
C1534	21-13743B29
C1535	21-13743N40
C1536	21-13743N40
C1537	21-13928N01
C1538	21-13743L11
C1539	21-13743N28
C1540	21-13743N40
C1541	21-13928N01
C1542	21-13743E20
C1545	21-13928N01
C1547	21-13743N40
C1550	21-13743E20
C1551	21-13743E20
C1552	23-11049A62
C1553	23-11049A62
C1555	23-11049A62
C1560	21-13743M24
C1562	21-13928L05
C1563	21-13928L05
C1564	21-13743L41
C1570	21-13743E20
C1571	21-13743E20
C1572	21-13743E20
C1574	21-13743N50
C1575	21-13743N50
C1580	21-13743N40
C1581	21-13743E20
C1582	21-13743N40
C1583	21-13743N40
C16	21-13743N26
C1700	21-13743M24
C1701	21-13743M24
C1702	21-13743M24
C1710	21-13743E20
C1711	21-13743N40
C1721	21-13743N40
C1722	23-11049A62
C18	21-13743N14
C1800	21-13743L41
C1801	21-13743E07
C1802	21-13743L25
C1803	21-13743N50
C1804	21-13743L41
C1805	21-13743L41
C18853	21-13743N50
C18858	21-13743N40
C18860	21-13743N40

Reference Designator	Part Number
C18861	21-13743E20
C18862	23-11049A62
C18871	21-13743L41
C18873	21-13743N30
C18874	21-13743N03
C19	21-13743N01
C1900	21-13743G26
C1902	21-13743M24
C1903	21-13743M24
C1904	21-13743M24
C1905	21-13743M24
C1906	21-13743M24
C1910	21-13743G26
C1911	21-13743N50
C20	21-13743N23
C201	21-13743N40
C202	21-13743N40
C203	21-13743N40
C204	21-13743L41
C205	21-13743N40
C21	21-13743N12
C22	21-13743N18
C23	21-13743N01
C24	21-13743L17
C25	21-13743L17
C251	21-13928C03
C252	21-13743F16
C253	21-13743L41
C261	21-13743L41
C262	21-13743F16
C263	21-13743L41
C272	21-13743L27
C273	21-13743L41
C274	21-13743L41
C30	21-13743N30
C300	21-13743N40
C302	21-13743L17
C303	23-11049A40
C304	21-13743N50
C305	21-13743L17
C306	21-13743E20
C307	21-13743N09
C308	21-13743L17
C309	21-13743L01
C31	21-13743N08
C310	21-13743L01
C311	21-13743N32
C312	21-13743N32

Reference Designator	Part Number
C313	21-13743L27
C315	21-13741A61
C316	21-13743N50
C317	21-13743L27
C32	21-13743N30
C33	21-13743N08
C333	21-13743N67
C334	21-13743L41
C335	21-13743N40
C339	21-13743N40
C34	21-13743N40
C342	21-13743N40
C35	21-13743L17
C350	21-13743N03
C351	06-62057M01
C36	21-13743N30
C37	24-09154M56
C38	21-13743N05
C389	21-13743N30
C395	21-13743L17
C399	21-13743L17
C40	24-09154M60
C400	21-13743N40
C401	21-13743N40
C402	21-13743L41
C404	21-13743N40
C405	21-13743N24
C406	21-13743N40
C407	21-13743N30
C41	21-13743N30
C410	21-13743N05
C411	21-13743N26
C412	21-13743N26
C413	21-13743N05
C414	21-13743N05
C42	21-13743N40
C425	21-13743N40
C426	21-13743L41
C427	21-13743N26
C43	21-13743N40
C447	21-13743N26
C451	06-62057M74
C452	21-13743N20
C454	21-13743L17
C455	21-13928N01
C460	21-13740F05
C462	21-13743N40
C487	21-13743N40

Reference Designator	Part Number
C499	21-13743N67
C501	21-13743N28
C502	21-13743L41
C503	21-13743N28
C504	21-13743L41
C505	21-13743L41
C506	21-13743N28
C508	21-13743N40
C509	21-13743N40
C510	21-13743N09
C511	21-13743N13
C512	21-13743N28
C513	21-13743N28
C515	21-13743N09
C599	21-13743N50
C69	21-13743L17
C70	21-13743N38
C720	21-13743N40
C721	21-13743N28
C750	21-13743N40
C751	21-13743N40
C752	21-13743N40
C753	21-13743L17
C758	21-13743M24
C764	21-13743N40
C771	21-13743N28
C773	21-13743N40
C774	21-13743N28
C775	21-13743N40
C776	21-13743N28
C777	21-13740F05
C778	21-13743N50
C780	21-13743N50
C783	21-13743N01
C800	21-13743N40
C802	21-13743N24
C803	21-13743N15
C804	21-13743N40
C805	21-13743N40
C806	21-13743N26
C809	21-13743N23
C810	21-13743N24
C811	21-13743N11
C812	21-13743N40
C813	21-13743N15
C814	21-13743N69
C815	21-13743N40
C821	21-13743N40

Reference Designator	Part Number
C822	21-13743N40
C823	21-13743N15
C824	21-13743N69
C825	21-13743L17
C826	21-13743N40
C827	21-13743L17
C828	21-13743N40
C829	23-03770S08
C830	21-13743N26
C831	21-13743N40
C833	21-13743N14
C834	21-13743N14
C835	21-13743L17
C882	21-13741F41
C883	21-13741F25
C884	08-09084T44
C885	21-13740F67
C886	21-09370C01
C887	21-13741F25
C888	21-13743N40
C898	21-13743L41
C899	21-13743N40
C901	21-13743N30
C903	21-13743N17
C904	21-13743N24
C906	21-13743N24
C907	21-13743N24
C911	21-13743N09
C912	21-13743N08
C913	21-13743N12
C914	21-13743N09
C915	21-13743M24
C920	21-13743N11
C9910	21-13743N40
C998	21-13928N01
CR100	48-09877C08
CR1001	48-09606E07
CR1051	48-09118D02
CR1070	48-09788E06
CR1071	48-09788E06
CR1072	48-13830A70
CR1100	48-09788E06
CR1540	48-09606E08
CR1541	48-09606E02
CR1555	48-09653F07
CR1560	48-09606E08
CR1561	48-09606E02
CR1562	48-09653F07

Reference Designator	Part Number
CR300	48-09877C08
CR301	48-09877C08
CR302	48-09948D13
CR501	48-09948D33
CR502	48-09948D33
CR503	48-09948D12
CR504	48-09948D33
CR730	48-09606E02
CR750	48-13830A70
CR751	48-09788E06
CR810	48-09606E02
CR821	48-09948D12
CR822	48-09948D12
CR910	48-09606E02
FL10	91-03913K04
FL20	91-03917K02
FL30	91-85861J02
FL350	91-03913K06
FL413	91-85623G03
FL450	91-09361K01
FL452	91-03913K03
FL453	91-85911J01
FL454	91-03913K03
J3	09-09449B04
J600	09-09195E01|l
J650	09-09399T03
J810	39-09578M01
J811	39-09578M01
J812	39-09578M01
J813	39-09578M01
JFLEX	09-09059E01
JIB	28-09454C02
L100	24-09414M31
L101	24-09414M09
L11	24-09646M78
L12	24-09646M79
L13	24-09154M62
L150	24-62587Q53
L1550	24-09154M71
L18	24-09154M68
L20	24-09646M73
L21	24-09704K51
L22	21-13741A21
L23	24-04574Z13
L24	24-62587Q53
L302	24-09414M17
L303	24-09414M12
L31	24-09154M59

Reference Designator	Part Number
L32	24-09154M66
L34	24-09154M60
L351	24-62587V33
L361	24-09154M65
L378	24-09154M65
L400	24-09154M57
L401	24-09154M63
L403	24-09154M51
L404	24-09646M98
L405	24-09646M98
L406	24-09154M60
L407	24-09154M58
L450	24-09594M24
L451	24-09154M68
L452	24-09154M68
L502	24-09154M55
L503	24-09154M60
L504	24-09154M62
L69	24-09154M12
L782	24-09646M93
L783	24-09646M97
L784	24-09646M78
L785	24-09646M98
L786	24-09646M91
L800	24-09348J08
L802	24-09154M57
L803	24-09154M63
L813	24-09154M63
L821	24-09646M97
L822	24-09646M97
L833	24-09154M12
L901	24-09646M80
LS1	50-09365S01
Q1001	48-09579E02
Q1003	48-09579E02
Q1005	48-09605E02
Q1100	48-09579E29
Q1101	48-09579E36
Q1102	48-09939C02
Q15	48-09579E02
Q1501	48-09579E42
Q151	48-09579E24
Q1515	48-09939C04
Q152	48-09605E02
Q1551	48-09940E02
Q1561	48-09579E27
Q1562	48-09807C30
Q1563	48-09807C30

Reference Designator	Part Number
Q1571	48-09807C32
Q1573	48-09807C32
Q1574	48-09579E40
Q1710	48-09605E02
Q1711	48-09607E04
Q1712	48-09605E02
Q1720	51-09781E93
Q1721	48-09579E36
Q1722	48-09605E02
Q1802	48-09579E02
Q1803	48-09579E02
Q1804	48-09579E02
Q1831	48-09579E02
Q1832	48-09579E02
Q301	48-09579E02
Q351	48-09579E43
Q391	48-09527E24
Q401	48-09527E22
Q475	48-09579E42
Q501	48-09607E05
Q502	48-09527E18
Q503	48-09579E30
Q505	48-09579E02
Q600	48-09939C02
Q642	48-09579E39
Q69	48-09527E24
Q700	48-09579E02
Q702	48-09608E03
Q810	48-09579E24
Q811	48-09579E24
Q820	48-09607E05
Q821	48-09607E05
Q831	48-09807C32
Q833	48-09527E24
Q834	48-09579E24
Q880	48-09579E30
Q901	48-09807C32
Q910	48-09579E24
R10	06-62057N09
R1000	06-62057N03
R10004	06-62057M90
R1001	06-62057N03
R10013	06-62057N15
R10014	06-62057N15
R10017	06-62057M98
R10018	06-62057M38
R10019	06-62057N15
R10021	06-62057M98

Reference Designator	Part Number
R10023	06-62057M26
R10024	06-62057M66
R1005	06-62057M98
R1008	06-62057M98
R1009	06-62057M26
R1010	06-62057M98
R1011	06-62057N03
R1012	06-62057M74
R1013	06-62057M74
R1014	06-62057N23
R1020	06-62057M84
R1030	06-62057N09
R1031	06-62057N15
R1032	06-62057N15
R1036	06-62057M84
R1050	06-62057N15
R1056	06-62057N23
R1057	06-62057N23
R1058	06-62057M61
R1059	06-62057M50
R1070	06-62057M90
R1071	06-62057M50
R1090	06-62057M01
R1092	06-62057N15
R11	06-62057N09
R1100	06-62057V07
R1101	06-62057V02
R1102	06-62057M98
R1103	06-62057M98
R1105	06-62057N15
R1106	06-62057M98
R1200	06-62057M90
R1201	06-62057M98
R1203	06-62057M98
R1204	06-62057N23
R1205	06-62057M74
R121	06-62057M98
R122	06-62057M90
R131	06-62057M74
R145	06-62057M01
R15	06-62057N15
R151	06-62057N03
R1512	06-62057M01
R1513	06-62057M01
R1514	06-62057M01
R1515	06-62057M98
R1516	06-62057M98
R1517	06-62057M98

Reference Designator	Part Number
R1518	06-62057M98
R152	06-62057N15
R1521	06-62057N31
R1522	06-62057N23
R1523	06-62057M82
R1524	06-62057M98
R153	06-62057N09
R1530	06-62057N17
R1531	06-62057N09
R1532	06-62057N23
R1533	06-62057N31
R1534	06-62057M90
R1535	06-62057M66
R1536	06-62057M54
R1537	06-62057M98
R1538	06-62057M74
R1539	06-62057M36
R154	06-62057M67
R1540	06-62057N15
R1541	06-62057M58
R1550	06-62057M01
R1553	06-62057M98
R1554	06-62057N13
R1555	06-62057M01
R1561	06-62057M92
R1563	06-62057N15
R1564	06-62057N15
R1565	06-62057N47
R1566	06-09175L02
R1573	06-60076N49
R1574	06-62057N23
R1575	06-62057N47
R1576	06-62057M01
R1577	06-62057M01
R1580	06-62057M98
R1581	06-62057M82
R1590	06-62057M01
R1708	06-62057N33
R1711	06-62057N15
R1712	06-62057N23
R1713	06-62057N23
R1720	06-62057N23
R1800	06-62057N11
R1801	06-62057M01
R1804	06-62057M82
R1806	06-62057N16
R1810	06-62057N17
R1811	06-62057N17

Reference Designator	Part Number
R1820	06-62057N23
R1830	06-62057N15
R1831	06-62057M01
R1900	06-62057M26
R1901	06-62057M01
R1902	06-62057M01
R1905	06-62057M01
R1910	06-62057M90
R1911	06-62057N15
R1912	06-62057N11
R1913	06-62057N15
R1914	06-62057M01
R20	06-62057M86
R201	06-62057M43
R301	06-62057M72
R302	06-62057N17
R303	06-62057N01
R304	06-62057N13
R305	06-62057M81
R306	06-62057N06
R308	06-62057M54
R311	06-62057M43
R341	06-62057N13
R342	06-62057N07
R391	06-62057M96
R392	06-62057N03
R393	06-62057M64
R403	06-62057N13
R405	06-62057M34
R406	06-62057M85
R408	06-62057M26
R409	06-62057M82
R41	06-62057M43
R425	06-62057N13
R45	06-62057M26
R450	06-62057M50
R451	06-62057M43
R498	06-62057M98
R499	06-62057M98
R501	06-62057M46
R502	06-62057M98
R503	06-62057M90
R504	06-62057M90
R505	06-62057N11
R506	06-62057M76
R507	06-62057M62
R508	06-62057M38
R509	06-62057M62

Reference Designator	Part Number
R510	06-62057M50
R642	06-62057N23
R643	06-62057N23
R69	06-62057M39
R70	06-62057N17
R710	06-62057M82
R720	06-62057M74
R721	06-62057M74
R722	06-62057M74
R723	06-62057M74
R724	06-62057M74
R725	06-62057M74
R726	06-62057M74
R727	06-62057M74
R728	06-62057M74
R729	06-62057M74
R730	06-62057M90
R731	06-62057M74
R732	06-62057M74
R733	06-62057M74
R734	06-62057M74
R735	06-62057M74
R736	06-62057M74
R737	06-62057M74
R738	06-62057M74
R739	06-62057M74
R740	06-62057M74
R741	06-62057M74
R742	06-62057M74
R743	06-62057M74
R744	06-62057M74
R745	06-62057M74
R746	06-62057M74
R747	06-62057M74
R748	06-62057M74
R749	06-62057M74
R750	06-62057M74
R761	06-62057N15
R762	06-62057N15
R777	06-62057M50
R800	06-62057M61
R801	06-62057M26
R802	06-62057M95
R803	06-62057M78
R804	06-62057M36
R810	06-62057M98
R811	06-62057M76
R812	06-62057M43

Reference Designator	Part Number
R813	06-62057M36
R821	06-60076N36
R822	06-60076N36
R831	06-62057M98
R833	06-62057M39
R834	06-62057N19
R881	06-62057M92
R882	06-62057N03
R883	06-62057M92
R893	06-62057M94
R906	06-62057M82
R907	06-62057M80
R908	06-62057M66
R910	21-13743N28
R911	06-62057M66
R999	06-62057M28
S1	40-09060E04
S2	40-09060E04
S3	40-09060E04
U1000	51-09841C53
U1003	51-99423A01
U11	51-09940K33
U110	51-09879E24
U1100	51-09817F17
U1200	51-99404A01
U1300	51-09509A16
U150	48-09443R06
U1500	51-09879E42
U1501	51-09817F27
U1700	51-09962C16
U1800	51-09817F34
U1900	51-99400C02
U1901	51-99396A01
U301	51-09879E25
U306	48-09283D38
U411	48-87716K01
U700	51-09522E35
U701	51-09522E10
U704	51-09572E19
U801	51-09730C16
U901	51-09730C15
VR1500	48-09788E06
XFMR377	58-85758J03
Y1500	48-09995L08

Theory of Operation

Antenna Circuit

Two RF ports are designed in this transceiver; internal antenna and external antenna. An RF switch controls which antenna path is going to be used during operation.

The internal antenna will be used only when there is no load at the EXT_ANT port.

RX Front End IC

The Front End IC is used to remove the RX carrier frequency and produce the RX IF signal. It also has some internal buffers for the receive signals and the VCO signals.

The RX signal is amplified within the Front End IC and then routed to an exter-nal filter. The signal is then injected back into the Front End IC and is mixed with the VCO and the result is the IF signal which is filtered prior to entering the Custom IC.

Custom IC

The Custom IC can be divided into two functional subsystems: The ZIF (Zero-Intermediate-Frequency) which provides all of the functions of the back-end of a receiver, and the SYN (SYNthesizer) which contains phase-locked loops and modulators to produce the Local Oscillator (LO) and modulated transmit carrier.

The ZIF implements the back end of the receiver. The incoming signal is attenuated, amplified and mixed down to an extremely low frequency (Baseband)-not quite DC. The first amplifier and an Automatic Gain Control (AGC) circuit adjusts the amplifier gain to maintain a constant level in the baseband filter.

The first mixing that occurs in the ZIF requires a 2nd Local Oscillator that is running at 221.184MHz. The 2nd LO is divided down then phased shifted before being mixed with the IF signal., producing the baseband signal

The baseband signal is low-pass filtered using a programmable low-pass filter. In TDMA mode, the baseband signal is routed to the DCI via the RX_I and RX_Q lines. In analog mode, the baseband signal is up-converted and then FM-demodulated, producing the DEMOD signal which is routed to the DCI for filtering and de-emphasis.

The RSSI (Receive Signal Strength Indicator) is a voltage that increases with respect to the received signal strength. The RSSI signal has a filtering capacitance that changes with respect to the operating mode(e.i. analog, digital).

VCO

The VCO is a local oscillator module used to add frequency selectivity to the transceiver. The frequency of oscillation is dependent on the channel and band that the trans-ceiver will be operating in. The frequency is controlled by the Custom IC. The Custom IC will receive channel information via the SPI bus and adjust the frequency of the VCO by varying the voltage level to the input of the VCO.

The output of the VCO is split into two paths. One path is used to feed back the produced signal to the Custom IC. Then the signal is prescaled and sent through a phase lock loop circuit for frequency locking. The second path is sent to the receive circuit for carrier signal removal.

TX Offset Oscillator

The offset oscillator frequency is controlled by the Custom IC via TXCP_OUT. The operating frequency will depend on the dc biasing of CR300. The offset oscillator frequency is 157.32MHz in analog mode, and 112.32MHz in digital mode.

The LP_Switch, which comes from the Custom IC pin 40, changes the offset frequency. The LP_Switch is on in analog mode and off digital mode. The LP-Switch is currently not supported in the TDMA StarTAC, therefore, the frequency of the offset oscillator will be 157.32MHz regardl ess of whether it is in a nalog or digital mode.

In analog mode the FM signal comes from the DCI pin 39 and is modulated directly in the offset oscillator. The offset oscillator with the FM then enters QMOD. The Quadmod will feed back the offset frequency to the Custom IC for proper PLL operation.

Merlin IC

The Merlin IC is a TX modulator. It takes the TX information and modulates it on a carrier for RF transmission. In analog mode the offset oscillator with the FM enters the Merlin IC and gets mixed with the main VCO. The resulting signal is a differential carrier with the modulated information. The carrier is then passed through an IQ modulator.

The A_D line controls the state of the IQ modulator. In analog mode, the IQ modulator simply feeds the carrier through to a voltage controlled amplifier(VCA). The gain of the VCA is controlled via the AOC_CNTL line, therefore, controlling the TX power steps of the transceiver. Once the carrier passes through the VCA, it passes through the cellular final power amplifier which is still internal to the Merlin IC
.
In digital mode the offset oscillator doesn't contain the modulated information from the FM line. The offset oscillator is mixed with the main VCO and a differential out-put signal is sent through the IQ modulator. In digital mode, the A_D line configures the IQ modulator to allow IQ modulation to the carrier. The result carrier signal is then passed through the Voltage Controlled Amplifier (VCA). The gain of the VCA is adjusted by the AOC_CNTL line, thus controlling the TX digital power steps of the transceiver. The carrier is then routed through the cellular final power amplifier and out to the transmit circuit.

Amp Drivers

After the desired transmit information is modulated with a TX carrier frequency, enough signal power needs to be provided for RF transmission through the antenna. The driver stage is used to relieve amplification of the final stage PA. This reduces excess heat dissipation and overloading of the final stage PA.

The TX signal passses through FL452 and then is amplified by Driver Amp Q401. It then passes through Band Pass Filter FL454 before continuing to the final stage PA.

The output of Q810 is used to provide the biasing voltage for the final stage PA(U801). The 800BIAS voltage level determines the operating condition of the final stage PA. A lower voltage level at 800BIAS denotes digital mode and a higher voltage level denotes analog mode.

PA Circuit

The final stage PA circuit provides the necessary amount of power for RF trasmission through an antenna. U801 is a PA module that is capable of operating in the 800MHz band under analog or digital mode.

In analog mode linearity of the PA is not as critical as when operating in digital mode. For this reason, efficiency is a more important factor than linearity when operating in analog mode.

In digital mode, because of its IQ modulation scheme, PA linearity is a more important factor than efficiency. Efficiency and linearity is controlled by varying the biasing of the PA(U801). Q831 controls the supply voltage to U801. The PA supply is sourced from the B+ line.

After the TX carrier is amplified it is sent to the duplex filter for final transmission through the antenna. In order to maintain a accurate power level, an RF detect circuit is used to monitor the signal level being transmitted.

RF Detect Circuit

The RF detect circuit is used to detect the RF amplitude level of the TX signal. RF detect reports back to the DCI pin 31, using a dc level, for amplitude stabilization. The RF detect circuit is RF coupled with the TX signal. The RF input is then converted into a dc level and sent to the RF_DETECT line.

There are two stages in the RF detect circuit which are used to increase the dynamic range of the RF detect output. The two stages are controlled by the TX_STEP line input. TX_STEP is high when power steps 0 through 5 are used . TX_STEP is low when power steps 6 through 10 are used. During low power steps the signal is sent directly to the RF _DET output through CR504. During high power steps the signal passes through amplifier Q502 and then sent to the RF_DET output through CR502.

Analog/Digital Switch

The switching circuits are used to define the proper PA loads when in analog mode or digital mode.

When a high PA supply voltage is present, the PA may begin dissipating more heat. This may cause overheating to the Call Processor(U1000). To protect the U1000 from overheating, power is reduced by switching loads.

DCI (U1800)

The DCI(U1800) is the data converter interface between the DSP and the RF functions of a TDMA transceiver. It incorporates the following functions:

- Dual channel forward data I and Q(RX_I & RX_Q)
- Two DACs for reverse data I and Q(TX_I & tx_Q)
- DAC for AFC
- DAC for AGC & DAC for reverse PA control
- DAC for PA bias
- Serial Synchronous Interface(SSI)
- Serial Peripheral Interface(SPI)
- Countdown timer for call processor wake-up
- Free-running Real Time Counter to keep track of the time when control processor is stopped
- Internally generates clocks from single master input
- Power saving power-down modes
- Analog wide band forward data signalling functions with SPI interface
- Analog modulator interface
- Analog discriminator interfaces
- RF Discontinuous Receive during Manchester decoding
- On chip voltage reference for transmit I and Q

GCAP2 (U1500)

The GCAP2(U1500) provides the regulators and start-up functions for the entire radio. The GCAP2 contains the following hardware blocks:

- On/Off control signals to properly activate the radio.
- Bandgap reference voltage
- Audio amplification for the speaker
- Audio amplification for the alert
- Audio amplification for the EXT speaker
- Audio amplification of the microphone
- Audio CODEC
- Op-amps for use in the battery charger
- Internal D/A for the battery charger
- 8 channel, 8 bit A/D
- Real Time Clock
- Linear regulators
    - RX_2.75V for RX circuits
    - 2.75V for logic circuits
    - TX_2.75V for TX circuits
    - 5V for negative regulator
    - REF_2.75V for negative regulator reference
- 3 wire bus A/D
- Battery selection control circuitry

Audio/Thermistor

The cellular transceiver has the capability of supporting two batteries, a main battery and an auxiliary battery. Since a charger circuit is designed in this unit, there needs to be a form of reading the thermistor values of each battery separately. The thermistor readings are used to determine the temperature of the battery cell which is being charged.

In order for the call processor(U1000) to read the thermistor values of the batteries, a voltage needs to be placed across the thermistor. As the temperature increases the thermistor will decrease in resistance, causing the supply level at the thermistor to decrease. The thermistor line is pulled high by the THERM_BIAS line.

The transceiver supports three audio output ports; ear speaker (EAR-), headset speaker (HDST_SPKR), and external audio port (AUDIO_OUT). The audio path routing is controlled by the GCAP2. The call processor(U1000) programs the GCAP2 to route the audio to its proper path. When the transceiver determines that audio needs to be routed externally, the other two audio ports are disabled by the GCAP2(U1500). The audio comes from the EXT_OUT line and passes through an audio filter before being sent to the external connector. Because the AUDIO_OUT line has two multiplexed functions, the audio filter also acts as an isolator to the ON/OFF function which in the same line.

When the ear speaker is used, the EAR- and EAR+ lines are used . The audio signals between EAR+ and EAR- is 180° out of phase. This allows proper operation of the ear speaker.

When a headset is attached to the transceiver, a headset detect interrupt will have the audio only go to the headset speaker (HDST_SPKR). Since the same EAR- line is used for the headset and the ear speaker, the ear speaker is disabled by inverting the EAR- signal 180°. This will present two signals to the ear speaker that have no phase shift, thus, not allowing the ear speaker from functioning.

Charger/Batt Select

The internal charger will be activated only when there is an external power source, a Motorola battery is attached, the MAN_TEST line is loaded down, and BATT_FDBK is enabled. As SW_EXT_B+ passes thru R1566, U1500(GCAP) reads the charge current for proper control of the charger. CHRGC controls the rate of charge to the batteries by varying the gate biasing of Q1561.

The output of Q1561 is split into two different sections. The one section is the BATT_FDBAK line. BATT_FDBK_EN switches Q642 on or off to disable or enable BATT_FDBAK. When BATT_FDBK is not available, the external supply will lower it's supply to a normal operating voltage and the internal charger will be turned. The second section is the line to charge the batteries. The radio is capable of charging two batteries (Main and Auxiliary). The phone is designed to always charge the main battery first. Once the main battery is fully charged, it will begin charging the auxiliary battery.

Lines CHGR_MAIN_BATT and CHGR_AUX_BATT selects which battery will be charged. The dual transistor package Q600 has its outputs controlled by CHGR_MAIN_BATT and CHGR_AUX_BATT. Each line output of Q600 turns on or off charge transistors Q1562 and Q1563. When Q1562 is turned on, the main battery will be charged. When Q1563 is turned on, the auxiliary battery will be charged.

U1570 (ABC) is used to select the B+ supply source of the radio. SW_EXT_B+ takes priority over any other source for the B+ power source.

DOUB Supply/Backlight

There are some circuits that require a voltage higher than the battery source. For this reason, a voltage doubling charge pump circuit is provided. U1501 takes the 2.75V source and oscillates it with a high peak to peak signal. The positive region of the signal is then sent out to produced the VDOUB supply. When the transceiver is in sleep mode, U1501 is disabled and the VDOUB supply will be the same level as the 2.75V supply.

The display backlighting is controlled by the Call processor(U1000). U1000 sends a control signal via the BACKLIGHTING line. A high state at the BACKLIGHTING line will switch Q1720 on. This will allow B+ to supply the BKLT_CNTL line. As a result, the display backlighting will illuminated.

Reference Oscillator

The reference oscillator U150, operating at 19.44MHz, it provides a "reference frequency" for the RF synthesizers and various logic circuits. U1000 (CPU) switches U150 on and off via the OSC_DIS line. The Osc_DIS line switches Q151 on or off, controlling the supply voltage to U150 and Q152.

U1800 can "fine tune" U150 via the AFC line. Tuning of the reference oscillator is needed to synchronize frequencies with the cellular base station, therefore, the signal received from the base will be used to determine the correct reference frequency. The ouput of U150 is split into two signals. RF19.44MHz is used for the RF frequency reference and it is also amplified by Q152 and sent to the logic section for logic clock synchronization.

STUART (U1700)

The STUART IC(U1700) is a custom gate array that uses the following functions:

Host Port Emulation - This provides a bus interconnection between the call processor and the DSP via the call processor's parallel memory bus, interconnected to the modem DSP's parallel memory bus. This communications port is functionally identical to the host port provided for the Motorola DSP; To both devices, the port appears as a bus-mapped peripheral. The call processor sees the port as an 8-address block in memory at a location determined by the call processor's programming of its own chip select for the STUART IC. The DSP sees the port as an 8-address block in I/O space. Because the STUART IC uses the high byte of the DSP's bus, provisions are made for byte/word con-

version, to be compatible with the existing word-wide communications with U1000(Call processor).

DSP Timer - It provides a timer function. This is a device, accessible to the DSP, which implement a continuously clocked timer, with rollover, a feature needed for modem functionality but difficult to implement with the ATT device. The ATT timer can be set up to either stop on count=0, or to repeat the last count interval. We need a counter that can be set up to interrupt at a particular point in time, and then keeps counting, so that real-time is preserved, and can be set for a future time interval. This timer has a clock that is coherent with the symbol rate.

General Purpose I/O - It provides a 4-bit general purpose I/O port, with programming data direction function, as an extension to the call processor bit I/O set.

RF SPI interface - Improved interface between the Call processor, DSP, and ZIFSYN for scanning requirements needed because of the PCS band.

Transmitter control logic - Transmitter keying and frequency band selection.

DSP (U1900)

The following list is a description of the DSP(U1900):

- ROM Mask Device(48K)
- Patch RAM space(16K)
- Fixed point MAC(multiply accumulator)
- 8-bit parallel interface
- 8-bit control I/O interface
- Dual serial I/O ports
- Two external interrupts
- Flexible power management including Sleep mode, Sleep with slow internal clock, and stop.
- Three modes of operation
    1. Actively running
    2. Light sleep - Clocks running, but lower power consumption
    3. Deep sleep - All clocks off, extremely low power consumption
- Digital Traffic Channel
    1. Acquiring and maintaining synchronization with the Digital Channel
    2. AFC, AGC, AOC control loops
    3. Vocoders (ACELP and VCELP)
    4. Channel equalization
    5. Channel decoding
    6. Channel encoding
    7. Audio functions
    8. MAHO measurements
- Digital Control channel
    1. Essentially DTC minus audio and vocoders
    2. ROCM instead of MAHO
    3. Modem goes into deep sleep for long periods
- Analog Control Channel
    1. No RX functions - modem in deep sleep
    2. Manchester Encoder
    3. Transmitter control
- Analog voice channel
    1. Audio processing
    2. SAT detection/Transponding

Call Processor (U1000)

U1000 is a single-chip microcontroller that controls major functions of the cellular phone. U1000 will perform the functions of both the master controller and keyboard processor. These functions include:

- Keypad interrupt and scanning
- Display driving
- Control of audio and RF hardware
- Call processing (signalling) software
  - ON/OFF control
  - EEPROM access
  - Synthesizer programming
  - Automatic Frequency Control(AFC)
  - Transmit power setting
- User Interface

U1000 is not packaged with internal memories as past Call processors. This means that vital information that was previously stored in the memory of previous call pro-cessors is now stored in the external EEPROM(U1003).

Memory

A serial EEPROM(U1003) of 256K bytes is used for storage of the NAM information, authentication keys, phasing data, ESN, and memory. The EEPROM serial interface to the microcontroller is a standard SPI-compatible interface.

U1300 is a 64K x 16 low voltage, low power SRAM. U1300 uses a parallel interface bus.

U1200 is a 512K x 8 flash EPROM. U1200 uses a parallel interface bus.

Analog TX Audio Processing

The analog voice signal is taken from the microphone and digitized by the CODEC using an A/D converter. This block also contains filtering to remove aliases before sampling. The audio samples are then transmitted to the DSP. The transmit audio functions are located in a DSP.

The nominal TX Mic. Audio adjust amplifier is realized in software.

The 300 Hz. high-pass filter is realized using four poles and four zeros of IIR digital filtering. The 3 kHz. low-pass filter is realized using four poles and four zeros of IIR digital filtering.

The compressor is realized using a software variable gain amplifier. The gain of the stage is controlled by detecting the power at its output and applying the result to control the gain of the amplifier. The power detector is realized using a full wave rectifier and one pole and one zero of low-pass IIR digital filtering.

The pre-emphasis filter is achieved using one pole and one zero of IIR digital filtering. This stage also incorporates an up-shelf filter which is realized using one pole and one zero of IIR digital filtering.

The deviation limiter is realized using an amplifier in conjunction with a 7th-order odd polynomial with two output comparators. The amplifier is realized in software. The 7th-order odd polynomial minimizes the amount of spectral splatter and is realized in software. The comparators switch as the signal reaches a high or low threshold, thus,

limiting the output swing. The comparators are realized in software.

The post-limiter splatter filter is realized using a 17-tap FIR digital filter. This stage includes a down-shelf filter realized using one pole and one zero of IIR digital filtering. The up- and down-shelf filters work together with the splatter filter to limit the maximum deviation of the transmitter. The TX Mic. Audio mute is realized in software.

Data/Signaling Tone (ST) is generated as a sinusoidal signal using a look-up table. This method produces less harmonic energy than pure "Manchester" encoding would generate, easing the requirements for filtering of this signal.

DTMF is generated using look-up tables and SAT processing is also performed in the Transmit Audio Circuitry.
The summing of all Analog Transmit Modulation signals (Mic. Audio, Data/ST, DTMF and SAT) is performed in software.

The D/A converts the audio samples to an analog signal. The resultant analog waveform is filtered by a 5th-order low-pass switched-capacitor filter and a two-pole, two-zero continuous-time filter to remove aliases. The Master Deviation Adjust is realized by a digitally controlled amplifier. The resultant signal is then applied to the Analog Mod. input of the synthesizer circuit.

Digital TX Audio Processing

The analog voice signal is taken from the microphone and digitized by the CODEC using an A/D converter. The codec also contains filtering to remove aliases before sampling. The audio samples are then transmitted to the DSP.

In the DSP, microphone compensation and echo cancellation is applied to the Tx audio. Following these processes, the DSP uses VSELP (Vector-Sum Excited Linear Prediction) to compress the 160 samples of voice data into 159 bits of voice data. After the data has been compressed, the DSP separates the voice data into class I and class II bits. A cyclic redundancy check (CRC) is performed on the most significant class I bits. The CRC is used during the decoding process to determine the validity of the class I bits. Redundancy is then added to the class I bits by performing a rate-1/2 convolutional encoding operation on the class I bits and the CRC. The redundancy is used during the decoding process to correct class I errors. The class II bits are not encoded. The rate-1/2 convolutionally encoded class I bits and the class II bits are then interleaved with speech data from adjacent speech frames. Interleaving is used during the decoding process to reduce the effects of burst errors. The DSP then combines system messages with the interleaved rate-1/2 convolutionally encoded class I bits and class II bits. The resultant bits are sent to a data converter to be modulated.

The data converter modulates the data using differential quadrature phase shift keying (DQPSK) to generate in-phase and quadrature-phase data. The in-phase and

quadrature-phase data is then processed by a 32-tap FIR digital filter which has a square root of raised cosine frequency response with a roll-off factor of 0.35. The subsequent in-phase and quadrature-phase bit streams are then converted to analog signals. The resultant analog waveforms are filtered to remove aliases and then transmitted.

Introduction

The service diagrams were carefully prepared to allow a Motorola certified technician to easily troubleshoot cellular phone failures. Our professional staff provided directional labels, color coded traces, measurement values and other guidelines to help a technician troubleshoot a cellular phone with speed and accuracy.

We worked hard in trying to provide the best service diagrams, therefore, to avoid clut-tered diagrams, we excluded some compo-nents from the service diagrams. Our professional staff carefully selected to excluded components that are unlikely to fail.

Test Point Measurements

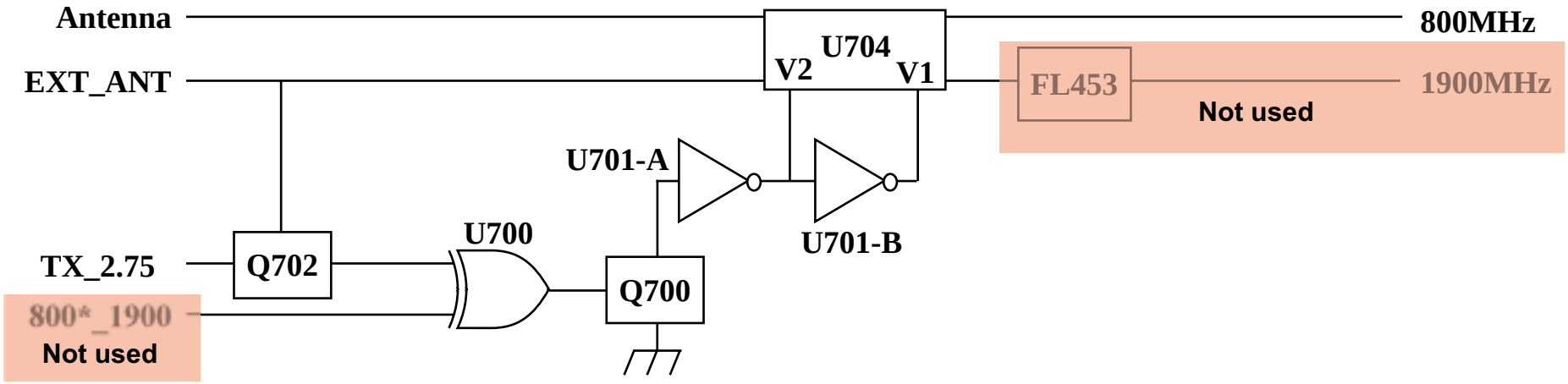
The measurements labeled on the service diagrams are approximate values and may vary slightly. These measurements are dependent on the accuracy of the test equipment.

It is strongly recommended that the test equipment calibration schedule be followed as stated by the manufacturer. RF probes should be calibrated for each frequency in which tests are going to be performed.

The types of probes used will also affect measurement values. Test probes and cables should be tested for RF losses and loose connections.

Because of the sensitivity of R F, measured readings will be greatly affected if they ’re taken in certain locations. To get the most accurate readings, take measurements nearest to the labeled measurement on the service diagram.

TDMA StarTAC™ P8190: Antenna Circuit



Description

A2

Two RF ports are designed in this transceiver; internal antenna and external antenna. The RF switch(U704) controls which antenna path is going to be used during operation. U704 has two control inputs which are used to control the RF routing.

The internal antenna will be used only when there is no load at the EXT_ANT port. The absence of a load at the EXT_ANT port will not bias the base of PNP transistor Q702 on. This condition will not allow TX_2.75 to be present at one of the inputs of the exclusive OR gate U700.

When a load is present at the EXT_ANT port, the base of Q702 is biased. This condition will switch Q702 off, allowing the input of U700 to be in a low state.

U700 only has one output which allows only two possible states, high or low. With this in consideration, U704 will also have only to possible states.

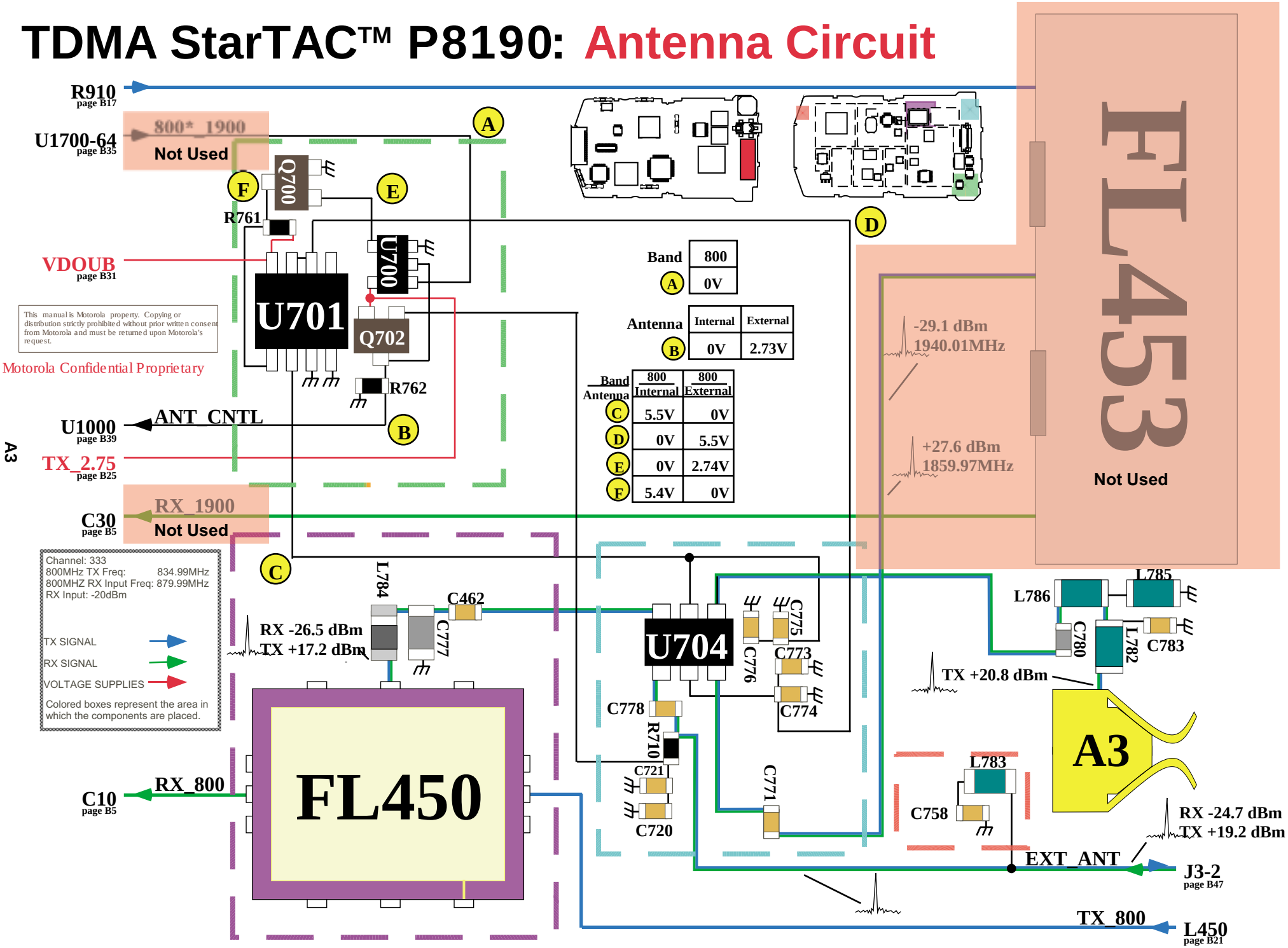
The states of U704 are determined by the output of U700. A low state at the output of U700 will switch Q700 on. This condition will pull the input the inverter U701-A low. The output of U701-A will provide a high state at V2. U701-B is then used to invert the state and provide a low state at V1. Having a low state at the output of U700 will invert all the states.

Having a high state at V2 and a low state at V1 will configure U704 to route the EXT_ANT port to the 800MHz RF path.

A low state at V2 and a high state at V1 will configure U704 to route the antenna port to the 800MHz RF path.

Only one RF port is used at a time, therefore, only one RF switch configuration is used while the other is irrevelent.

TDMA StarTAC™ P8190: Antenna Circuit



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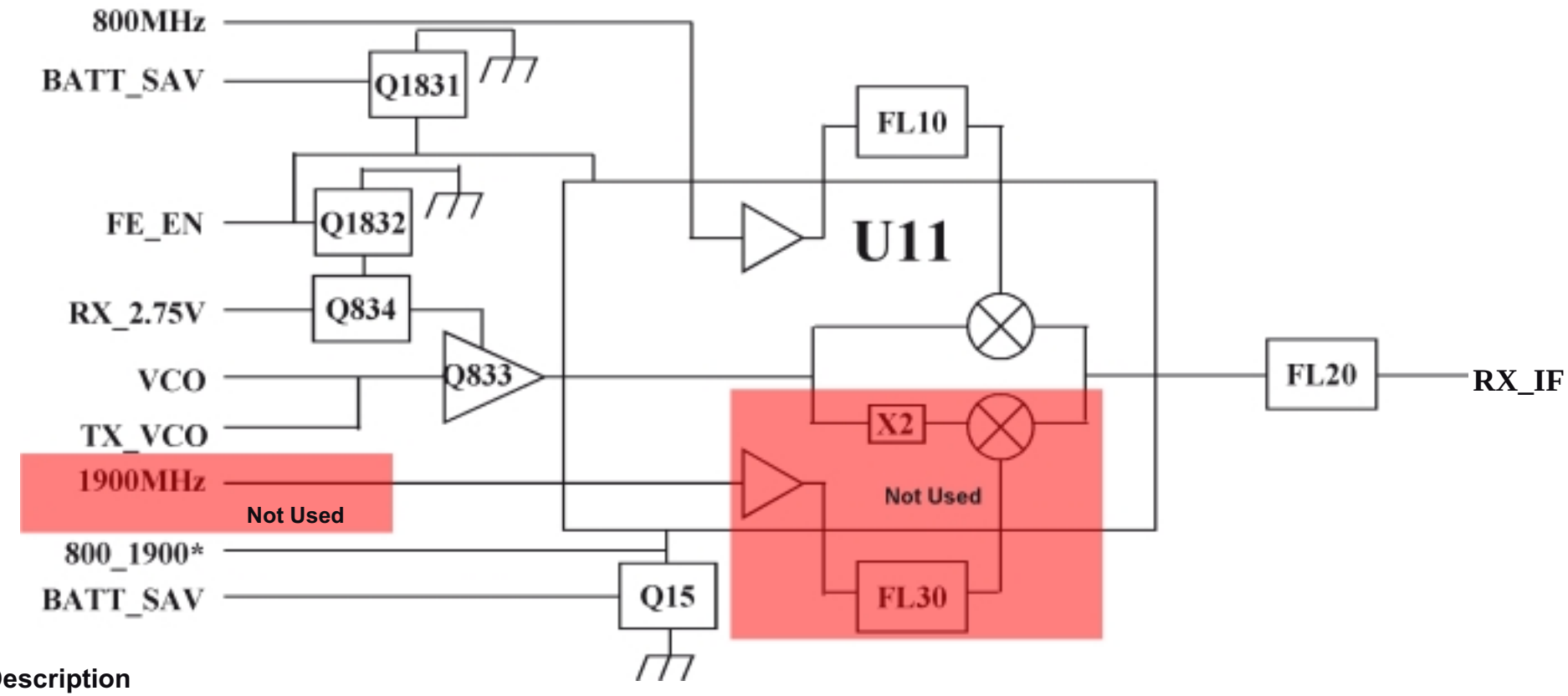
TDMA StarTAC™ P8190: RX Front End IC(U11)



A4

Description

The front end IC(U11) is used to remove the RX carrier frequency and produce the RX IF signal. U11 also has some internal buffers for the receive signals and the VCO signals.

U11 has two RF input ports. One is used for the 800MHz signal and the other is not used. The incoming signal is amplified within U11 and then routed to an external filter(FL10). The signal is then injected into the mixer of U11.

The receive signal is then mixed with the VCO and the result is the IF signal which is filtered by FL20 prior to entering the Custom IC(U110).

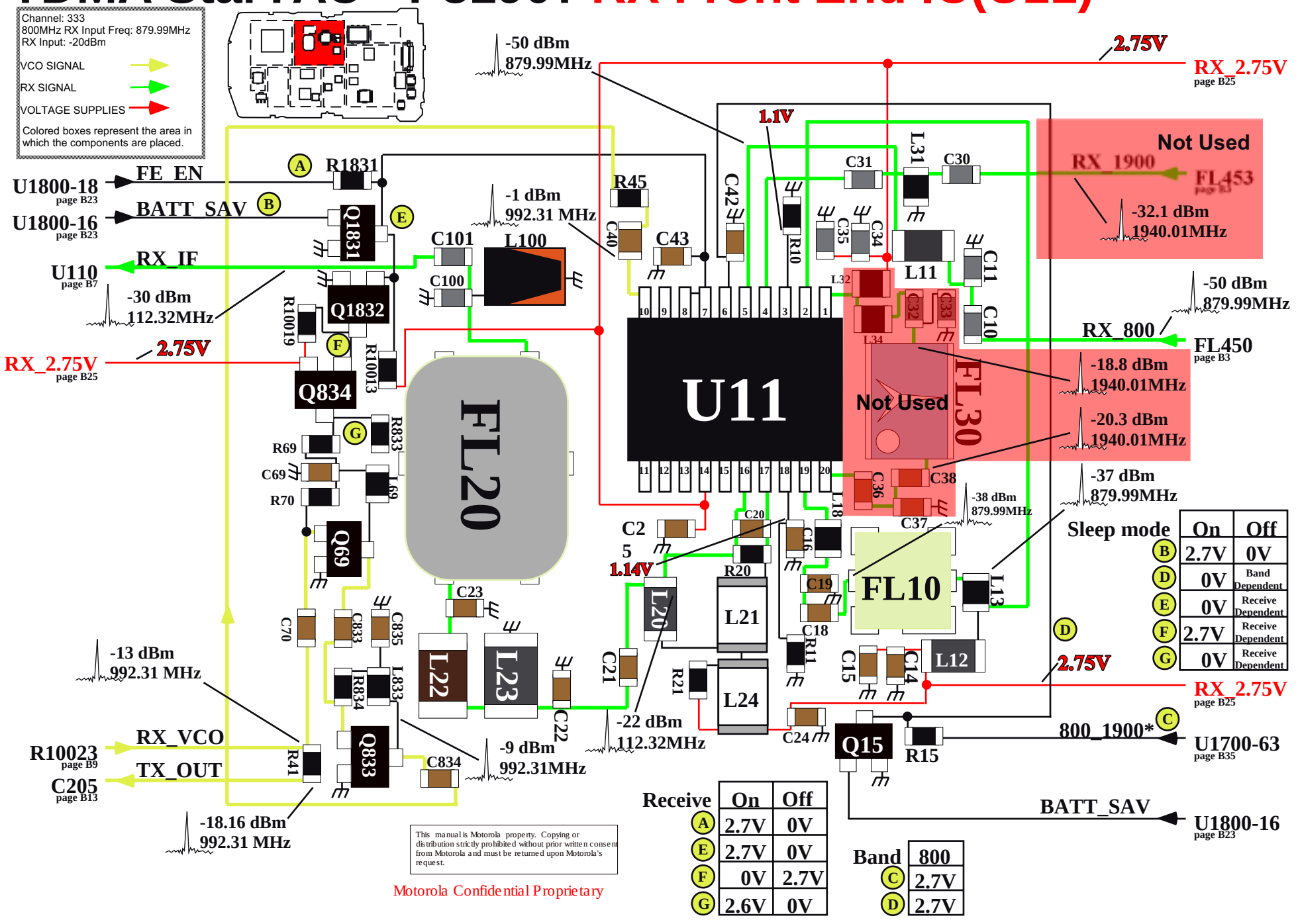
The VCO signal is amplified by Q833 prior to entering U11. The VCO signal is then routed to its proper path, depending on the operating mode.

800MHz mode is enabled via the 800_1900* line. Line 800_1900* is high in 800MHz mode.

Complete operation of U11 can also be disabled by the FE_EN line. A low state at FE_EN will disable U11. When the unit is in a sleep mode condition, the BAT_SAV line is pulled high. This state causes Q1831 to switch on, thus, grounding the FE_EN line. At the same time Q15 is switched on causing Q15 to ground line 800_1900*.

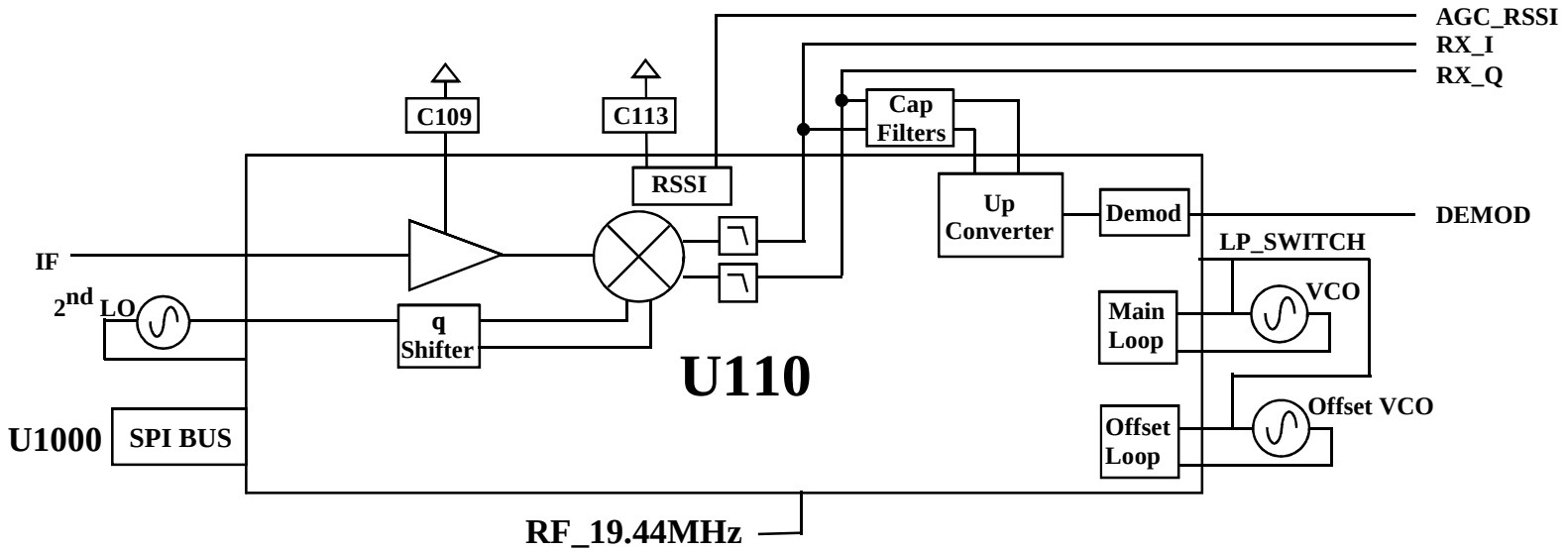
In addition to disabling U11 during sleep mode, Q833 is not supplied by RX_2.75V. This condition is caused by switching Q834 off. When FE_EN is grounded, Q1832 will be switched on. This will force the gate of Q834 to ground, thus turning off Q834.

TDMA StarTAC™ P8190: RX Front End IC(U11)



A5

TDMA StarTAC™ P8190: Custom IC(U110)



A6

Description

U110(Custom IC) can be divided into two functional subsystems: The ZIF (Zero-Intermediate-Frequency) which provides all of the functions of the back-end of a receiver, and the SYN (SYNthesizer) which contains phase-locked loops and modulators to produce the Local Oscillator (LO) and modulated transmit carrier.

The ZIF implements the back end of the receiver. The incoming signal is attenuated, amplified and mixed down to an extremely low frequency(Baseband)-not quite DC. The first amplifier and an Automatic Gain Control(AGC) circuit adjusts the amplifier gain to maintain a constant level in the baseband filter. C109 is used to add stability to the AGC circuit.

The first mixing that occurs in the ZIF requires a 2^{nd} Local Oscillator that is running at 221.184MHz. The 2nd LO is divided down then phased shifted before being mixed with the IF signal., producing the baseband signal

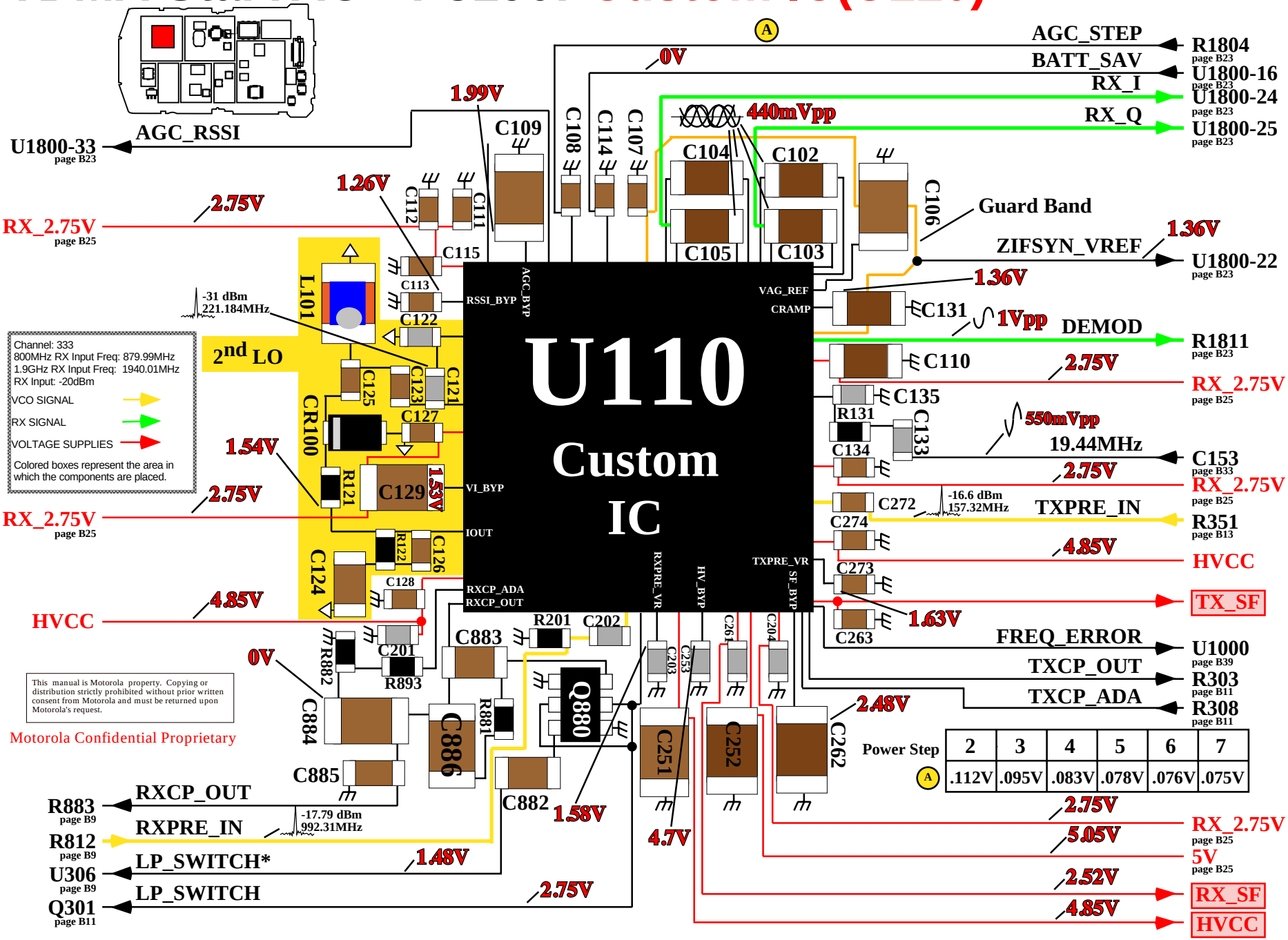
The baseband signal is low-pass filtered using a programmable low-pass filter. In TDMA mode, the baseband signal is routed to U1800(DCI) via the RX_I and RX_Q lines. In analog mode, the baseband signal is up-converted and then FM-demodulated, producing the DEMOD signal which is routed to U1800(DCI) for filtering and de-emphasis.

The RSSI(Receive Signal Strength Indicator) is a voltage that increases with respect to the received signal strength. The RSSI signal has a filtering capacitance() that changes with respect to the operating mode(e.i. analog, digital).

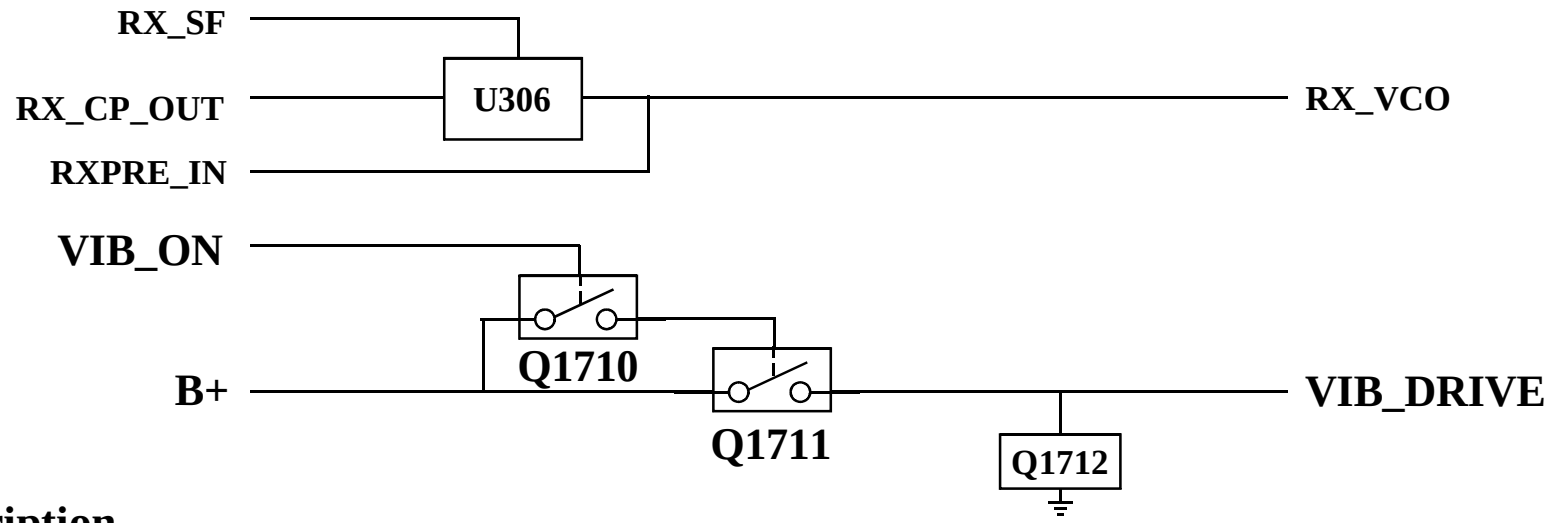
The SPI Bus is a serial interface used to program the internal filters and frequency dividers for U110, allowing selectivity of cellular channels.

RF 19.44Mhz input is used to provide a frequency reference for U110.

TDMA StarTAC™ P8190: Custom IC(U110)



TDMA StarTAC™ P8190: VCO/Vibrator



A8

Description

U306 is the local oscillator module used to add frequency selectivity to the transceiver. The frequency of oscillation is dependent on the channel that the transceiver will be operating in. The frequency is controlled by U110. U110 will receive channel information via the SPI bus and adjust the frquency of U306 by varying the voltage level to the input of U306.

The output of U306 is split into two paths. One path is used to feed back the produced signal to U110. The signal is prescaled and sent through a phase lock loop circuit for frequency locking. The second path is sent to the receive circuit for carrier signal removal.

U306 will oscillate at a frequency of 112.32+RX freuqency.

The vibrator is driven by Q1711. U1800 sends a vibrator on signal, via VIB_ON, to Q1710. Q1710 will trun on Q1711 thus allowing B+ supply the VIB_DRIVE line. Q1712 is configured as a diode and it's used to prevent the VIB_DRIVE line from going to a negative state.

TDMA StarTAC™ P8190: VCO/Vibrator

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Channel: 333
352# : Vibrator Enable
350# : Vibrator Disable

VCO SIGNAL

VOLTAGE SUPPLIES

Colored boxes represent the area in which the components are placed.

A9

U110 page B7 — RXCP_OUT — A — R883 — C887

Channel	2	333	799	
A	1.4V	1.79V	2.28V	800MHz

U306

RX_SF page B7 — 2.52V

C899 — C898 — R812 — R10023

-15 dBm@800MHHz
992.31MHz

C202 page B7 — RXPRE_IN

-8.03 dBm@800MHz
992.31MHz

RX_VCO — C833 page B5

D — VIB_DRIVE — JFLEX-9 page B47

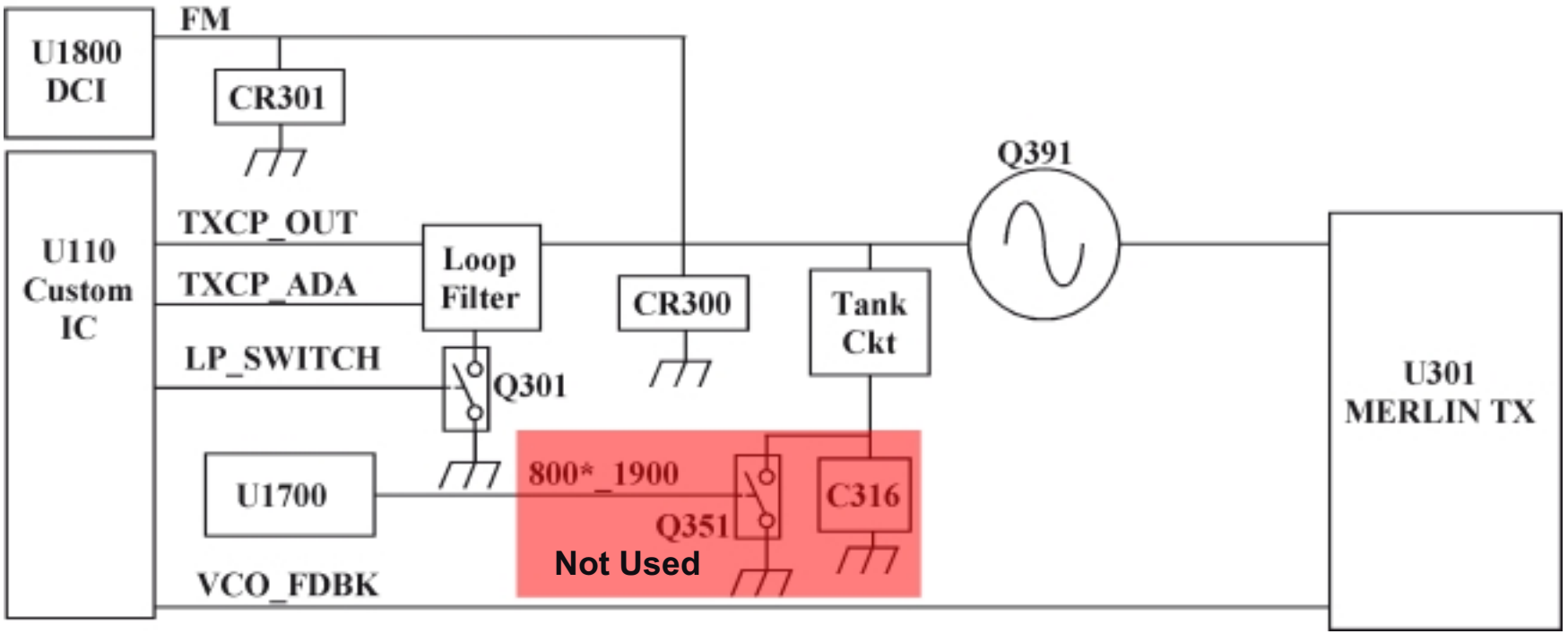
C1710 — C1711 — Q1712 — Q1711 — Q1710 — R1712

3.49V — B+ page B29

B — VIB_ON — R1711 page B35 — C

Vibrator	ON	OFF
B	1.86V	0V
C	2.79V	3.45V
D	1.27V	0V

TDMA StarTAC™ P8190: TX Offset Oscillator



Description

The offset oscillator frequency is controlled by U110(ZIF/SYN) via TXCP_OUT. The operating frequency will depend on the dc biasing of CR300. The offset oscillator frequency is 157.32MHz in analog mode, and 112.32MHz in digital mode. The LP_Switch, which comes from U110 pin 40, changes the offset frequency. The LP_Switch is on in analog mode and off digital mode. The LP-Switch is currently not supported in the TDMA StarTAC, therefore, the frequency of the offset oscillator will be 157.32MHz regardless of whether it is in analog or digital mode.

In analog mode the FM signal comes from U1800(DCI) pin 39 and is modulated directly in the offset oscillator. The offset oscillator with the FM then enters U300(QMOD). The Quadmod(U300) will feed back the offset frequency to U110 for proper PLL operation.

TDMA StarTAC™ P8190: TX Offset Oscillator

Channel: 333
800MHz RX Input Freq: 879.99MHz
RX Input: -20dBm
14# : ST On(FM test)

TX SIGNAL

VOLTAGE SUPPLIES

Colored boxes represent the area in which the components are placed.

Band	800
A	0V
B	2.79V
C	2.34V

Mode	Analog	Digital
D	2.79V	0V

C315 R301 R308 C302 Q301 C303 C304 R393 C312 C305 R303 C311 Q391 C350 R302 C309 CR300 C307 R392 C310 R391 C313 CR302 CR301 R304 R306 L302 L303 C306 C308 Not Used B C316 Q351 C399 C317 R305

C TXCP_OUT → U110 page B7

0V TXCP_ADA → U110 page B7

D LP_SWITCH → U110 page B7

0V

2.57V TX_SF page B7

1.08V

-21.44 dBm
157.32MHz
OVCO_B → U301-18 page B13

1.62V

2.57V

2.57V TX_SF page B7

0.9Vpp@10kHz FM → U1800-39 page B23

2.57V

A 800* 1900 → U1700-64 page B35

A11

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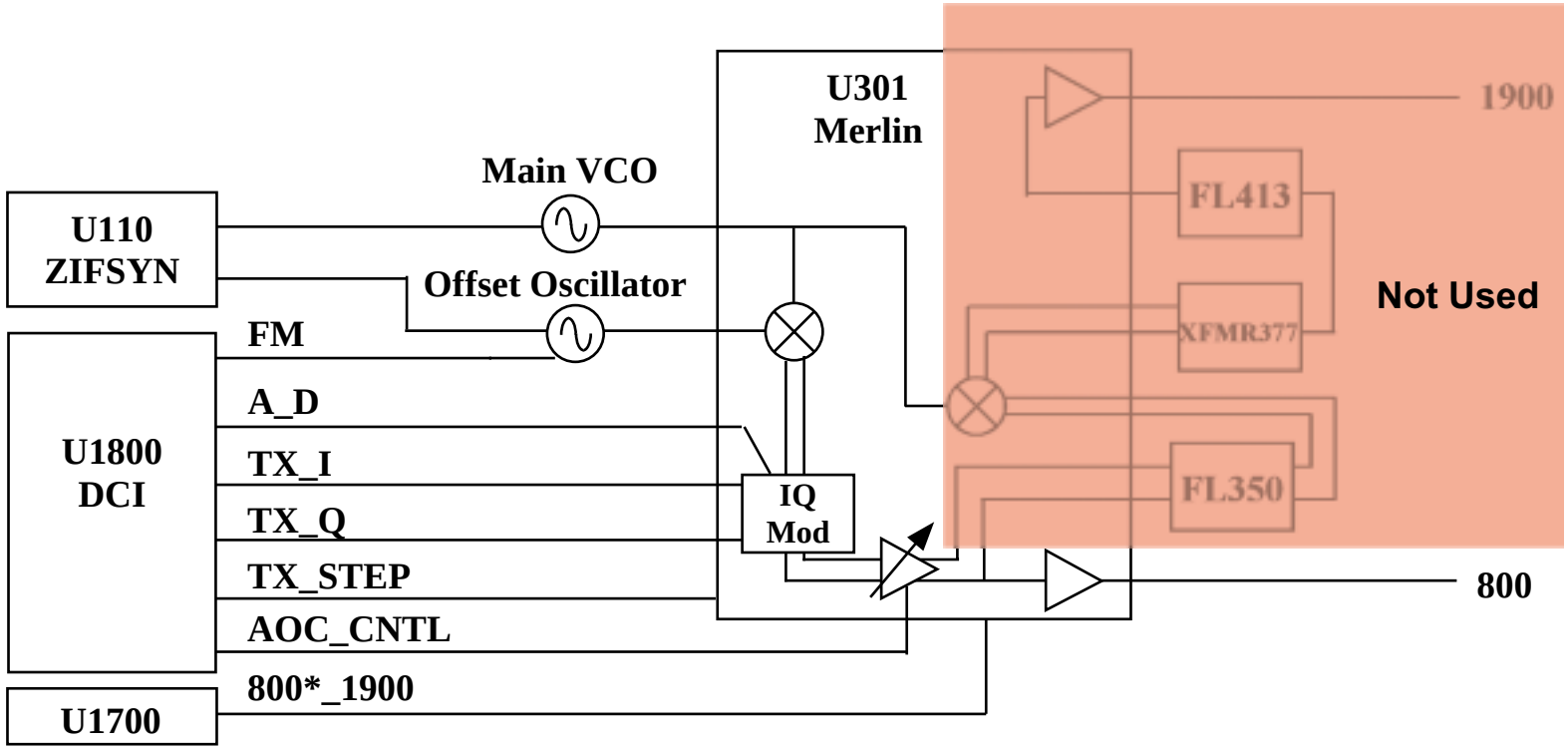
TDMA StarTAC™ P8190: Merlin TX(U301)



A12

Description

U301 is a TX modulator. It takes the TX information and modulates it on a carrier for RF transmission.

In analog mode the offset oscillator with the FM enters U301 and gets mixed with the main VCO. The resulting signal is a differential carrier with the modulated information. The carrier is then passed through an IQ modulator. The A_D line controls the state of the IQ modulator. In analog mode, the IQ modulator simply feeds the carrier through to a voltage controlled amplifier (VCA). The gain of the VCA is controlled via the AOC_CNTL line, therefore, controlling the TX power steps of the transceiver. Once the carrier passes through the VCA, it passes through the cellular final power amplifier which is still internal to U301.

In digital mode the offset oscillator doesn‘t contain the modulated information from the FM line. The offset oscillator is mixed with the main VCO and a differential output signal is sent through the IQ modulator. In digital mode, the A_D line configures the IQ modulator to allow IQ modulation to the carrier. The result carrier signal is then passed through the Voltage Controlled Amplifier(VCA). The gain of the VCA is adjusted by the AOC_CNTL line, thus controlling the TX digital power steps of the transceiver. Once the carrier passes through the VCA, it passes through the cellular final power amplifier and out to the transmit circuit.

The 800*_1900 line is used to enable or disable the final power amplifier.

The TX_STEP line is used to control the biasing to the cellular final amplifier. This line is used as a course gain control for the final amplifiers.

TDMA StarTAC™ P8190: Merlin TX (U301)

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Channel: 333
800MHz RX Input Freq: 879.99MHz
RX Input: -20dBm

VCO SIGNAL
RX SIGNAL
VOLTAGE SUPPLIES

Colored boxes represent the area in which the components are placed.

-16.93 dBm@800MHz
157.32 MHz

C272 page B7 ← TXPRE_IN → C351

TX_SF page B7 ← 2.57V → L351

FL413
Not Used

TX	On	Off
C	0V	2.79V

Band	800
D	0V

	Analog	Digital
E	2.82V	0V

-18.16 dBm@800MHz
992.31 MHz

R41 page B5 ← TX_VCO

TX_2.75 page B25 ← 2.81V

0.96V

R311, C205, C487, C334, C339

1.25V

C350 page B11 ← OVCO_B

U1800-20 page B23 ← QMOD_KEY (C)

TX_2.75 page B25 ← 2.81V

-21.2 dBm@800MHz
157.32 MHz

C454, C300, L452, C451, L451, C335, C425, R425, R403, C427, R341, R342, C18873, C18871, C342

C413, C402, C412, XFRM377, C426, C401, C389, C395, C447, L378, C361, C499, L401, C333

OVCO_E
OVCO_OUT
OVCO_VCC

U301

Not Used FL350

2.81V → TX_2.75 page B25

1.46 dBm
834.99MHz

TX_800 → FL452 page B15

TX_1900 → R408 page B15

2.81V → TX_2.75 page B25

TX_I → U1800-38 page B23

TX_IX → U1800-38 page B23

TX_Q → U1800-38 page B23

TX_QX → U1800-38 page B23

D → 800*_1900 → U1700-64 page B35

2.81V → TX_2.75 page B25

TX_2.75 page B25 ← A_D (E) → U1800-14 page B23

U1800-20 page B23 ← QMOD_KEY (C)

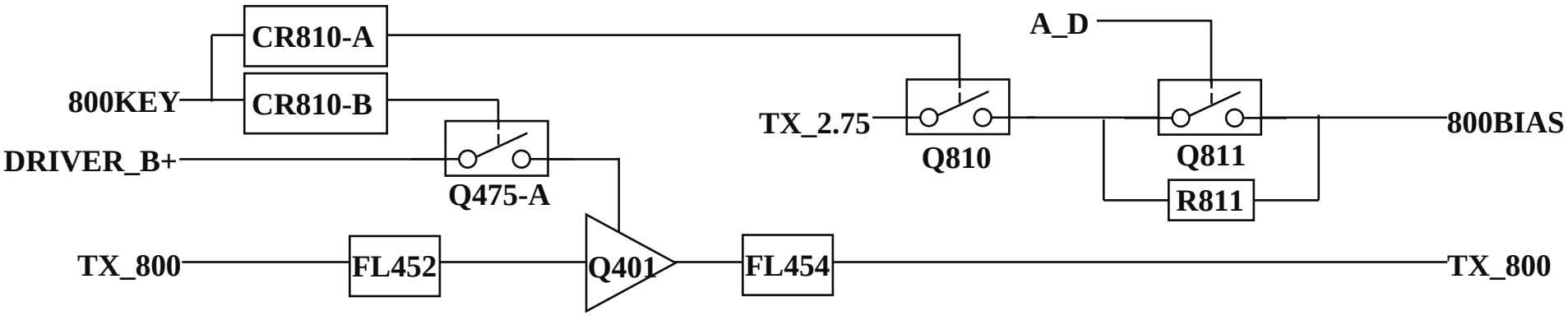
U1800-30 page B23 ← AOC_CNTL (A)

U1800-17 page B23 ← TX_STEP (B)

Power Step	2	3	4	5	6	7
A	1.4V	1.23V	1.08V	.965V	1.11V	1V
B	2.82V	2.81V	2.81V	2.81V	0V	0V

A13

TDMA StarTAC™ P8190: Amp Drivers



A14

Description

After the desired transmit information is modulated with a TX carrier frequency, enough signal power needs to be provided for RF transmission through the antenna. The driver stage is used to relieve amplification of the final stage PA. This reduces excess heat dissipation and overloading of the final stage PA.

The TX signal passes through FL452 and then is amplified by Q401. Q401 is driven on by suppling DRIVER_B+ through Q475-A. Q475-A can be switched on or off via the 800KEY line. A low state 800KEY brings the gate of Q475-A to a low level, causing Q475-A to switch on.

There are two operating modes in this unit, which are analog and digital. The output of Q810 is used to provide the biasing voltage for the final stage PA(U801). Q810 is switched on by having a low level at the gate.

The 800BIAS voltage level determines the operating condition of the final stage PA. A lower voltage level at 800BIAS denotes digital mode and a higher voltage level denotes analog mode. In analog mode, A_D is pulled high causing Q811 to be switched off. This state causes a voltage drop across R811, thus, having a lower voltage level at 800BIAS. In digital mode A_D is pulled low causing Q811 to be switched on. During this state R811 is bypassed and 800BIAS will have a higher voltage level.

TDMA StarTAC™ P8190: Amp Drivers

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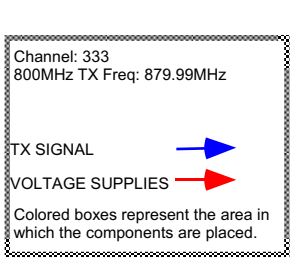
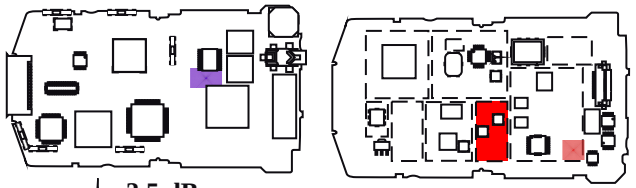
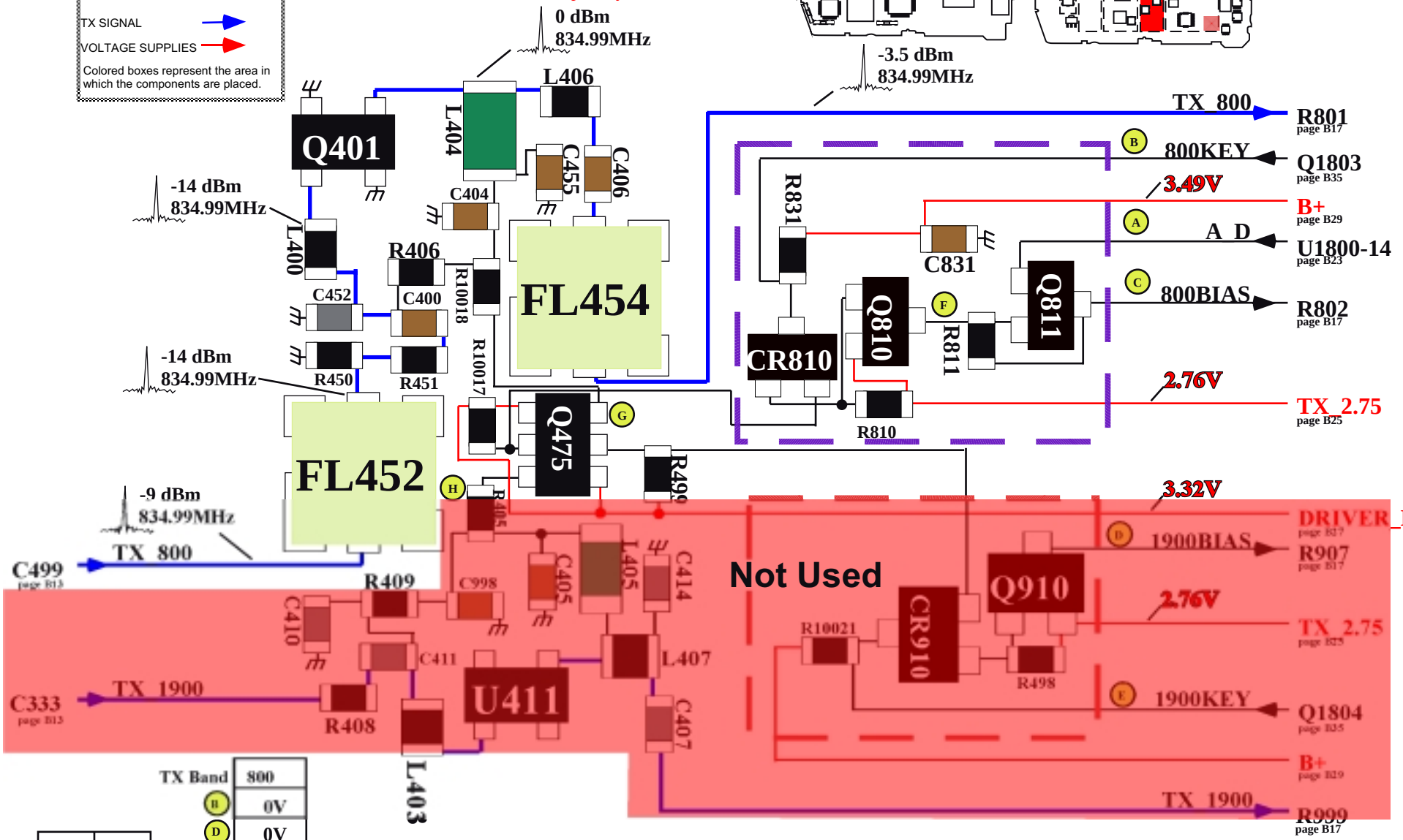

Channel: 333
800MHz TX Freq: 879.99MHz
TX SIGNAL
VOLTAGE SUPPLIES
Colored boxes represent the area in which the components are placed.



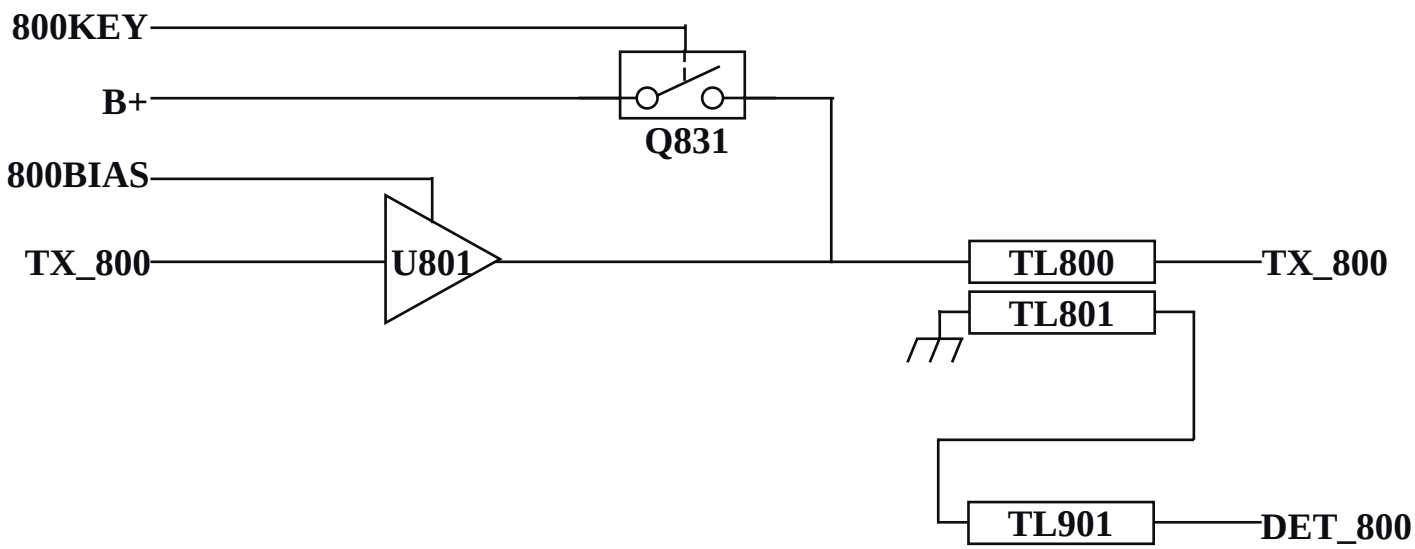


	Analog	Digital
A	2.82V	0V
C	2.06V	.889V

TX Band	800
B	0V
D	0V
E	3.36V
F	2.78V
G	3.38V
H	0V

A15

TDMA StarTAC™ P8190: PA Circuit



A16

Description

The final stage PA circuit provides the necessary amount of power for RF transmission through an antenna. U801 is a PA module that is capable of operating in the 800MHz band under analog or digital mode.

In analog mode linearity of the PA is not as critical as when operating in digital mode. For this reason, efficiency is a more important factor than linearity when operating in analog mode. In digital mode, because of its IQ modulation scheme, PA linearity is a more important factor than efficiency. Efficiency and linearity is controlled by varying the biasing of the PA(U801).

Q831 controls the supply voltage to U801. The PA supply is sourced from the B+ line. In 800MHz mode, 800KEY is held low causing Q831 to switch on. When 800KEY is pulled high, Q831 is turned off and the supply to U801 is cut off.

After the TX carrier is amplified it‘s sent to the duplex filter for final transmission through the antenna.

In order to maintain an accurate power level, an RF detect circuit is used to monitor the signal level being transmitted.

TDMA StarTAC™ P8190: PA Circuit

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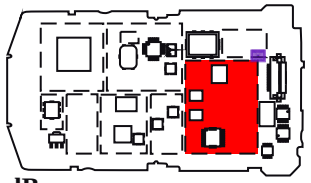
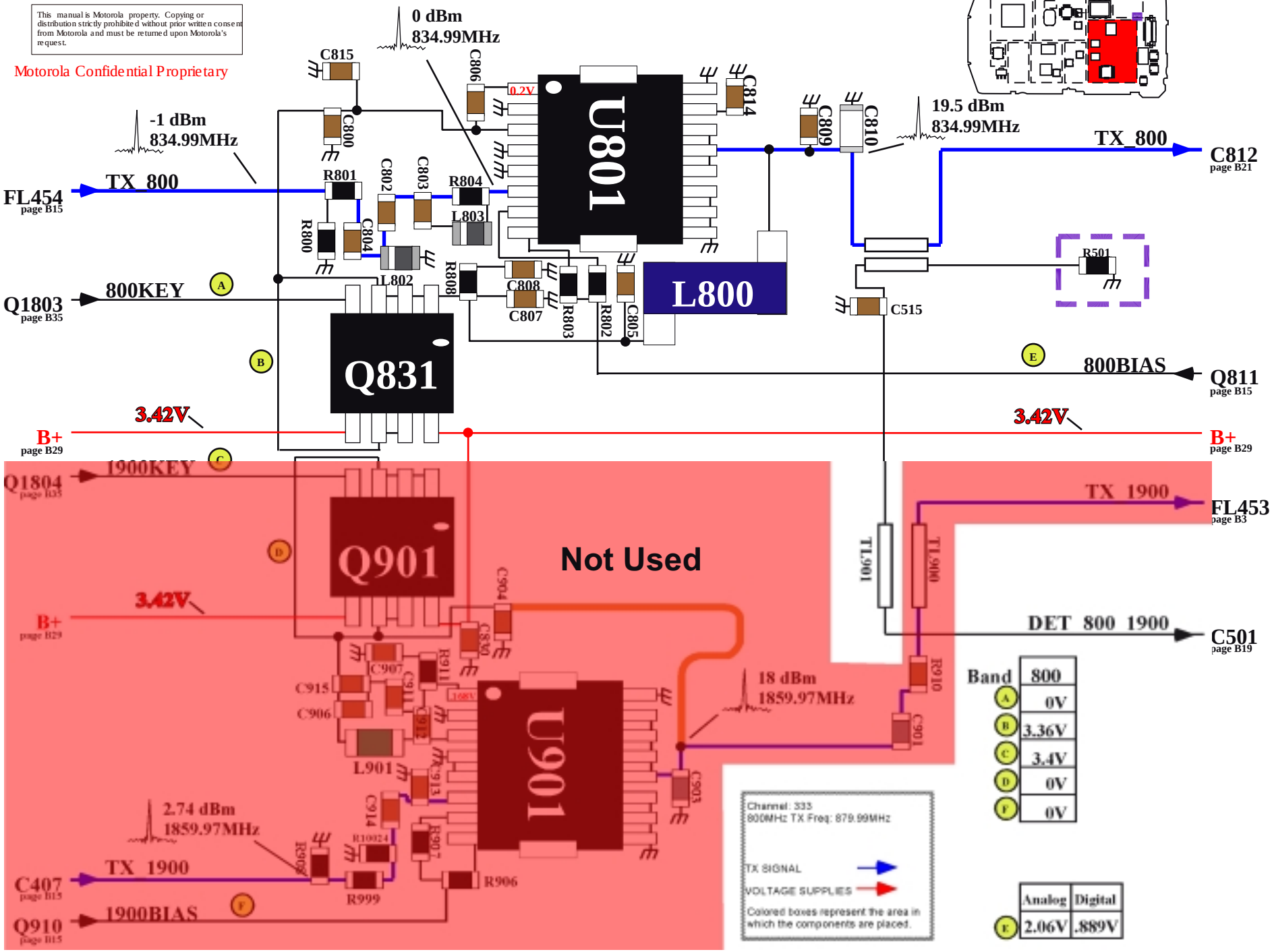
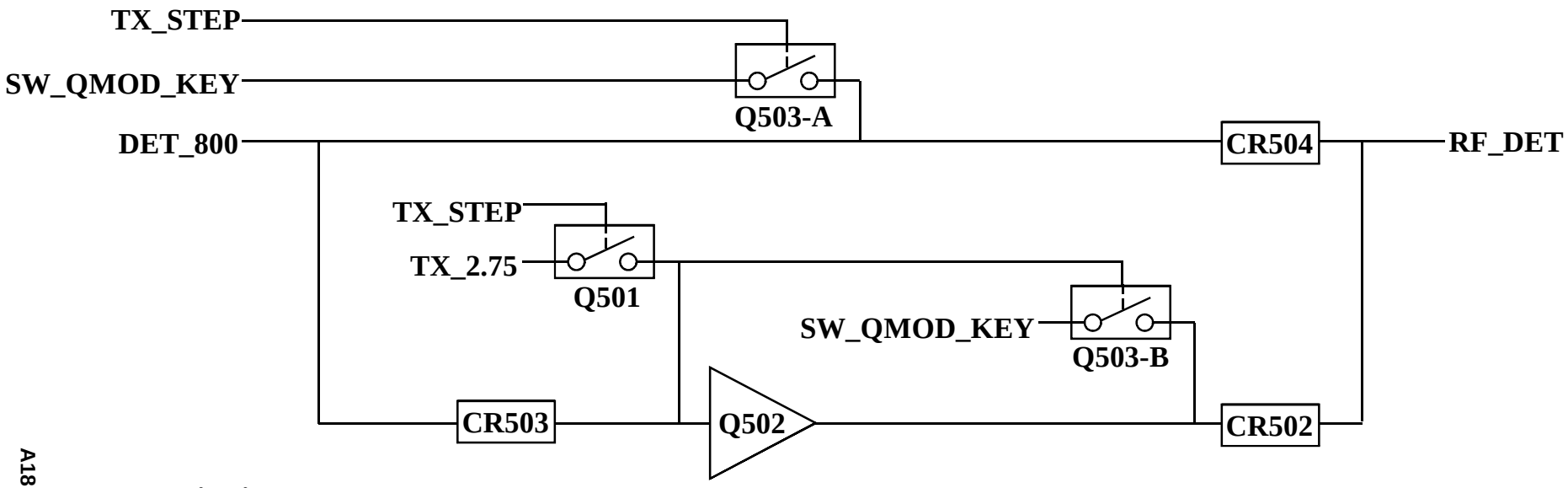


A17



TDMA StarTAC™ P8190: RF Detect Circuit



A18

Description

The RF detect circuit is used to detect the RF amplitude level of the TX signal. RF detect reports back to U1800(DCI) pin 31, using a dc level, for amplitude stabilization. The RF detect circuit is RF coupled with the TX signal. The RF input is then converted into a dc level and sent to the RF_DETECT line. There are two stages in the RF detect circuit which are used to increase the dynamic range of the RF detect output. The two stages are controlled by the TX_STEP line input. TX_STEP is high when power steps 0 through 5 are used . TX_STEP is low when power steps 6 through 10 are used .

When TX_STEP is low Q503-A is switched on and Q503-B is switched off. Q501 inverts the state of Q503-B. This operation forward biases diode CR504. At the same time it cuts off the supply to diode CR502, thus not forward biasing CR502. When TX_STEP is high Q503-A is switched off and Q503-B is switched on. This operation cuts off the supply to diode CR504. At the same time current is supplied to amplifier Q502 and CR502. During low power steps the signal is sent directly to the RF _DET output through CR504. During high power steps the signal passes through amplifier Q502 and then sent to the RF_DET output through CR502.

TDMA StarTAC™ P8190: RF Detect Circuit

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Channel: 333
800MHz TX Freq: 879.99MHz

VOLTAGE SUPPLIES →

Colored boxes represent the area in which the components are placed.

TX_STEP	ON	OFF
C	0.2V	0.65V
D	0.6V	0.19V
E	0.18V	1.21V
F	0.19V	2.76V

A19

U1800-17 page B23 → TX_STEP (A)

TX_2.75 page B25 → 2.76V

Q1501 page B27 → SW_QMOD_KEY → 2.75V

U1800-17 page B23 → TX_STEP (A)

R1806 page B23 → RF_DET (B)

2.76V

Q501, Q502, Q503

CR501, CR502, CR503, CR504

R502, R504, R505, R506, R507, R508, R509, R510, R503

C501, C502, C503, C504, C505, C506, C508, C509, C510, C511, C512, C513

L502, L503, L504

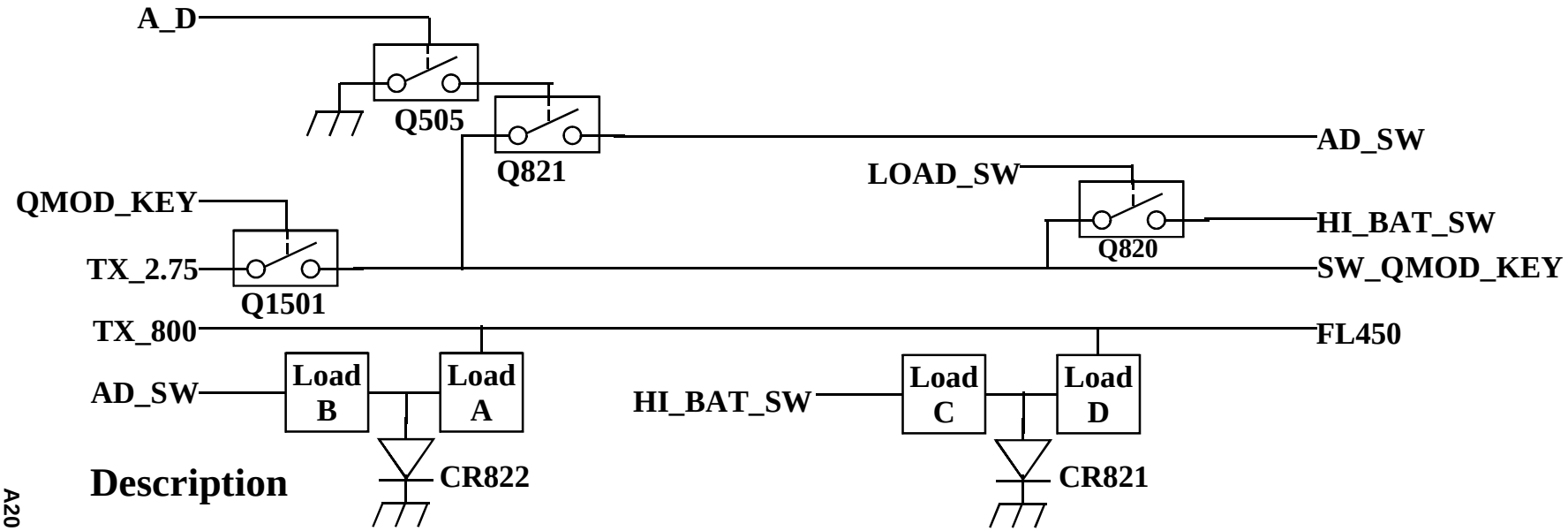
(C)

DET_800 → TL901 page B17

0V

Power Step	2	3	4	5	6	7
A	2.8V	2.76V	2.75V	2.75V	0V	0V
B	1.17V	.88V	.6V	.43V	1.5V	.98V

TDMA StarTAC™ P8190: Analog/Digital Switch



A20

The switching circuits illustrated above are used to define the proper PA loads when operating in analog or in digital mode.

Q1501 is a FET switching circuit which allows SW_QMOD_KEY to be sourced from the TX_2.75 supply. During non-transmit states, Q1501 is switched off by pulling QMOD_KEY high. This state will not allow SW_QMOD_KEY to be sourced from TX_2.75, thus reducing unnecessary current consumption in numerous TX circuits that use the SW_QMOD_KEY supply.

When transmitting in analog mode, LOAD A is used and LOAD B is bypassed. LOAD B is bypassed by allowing CR822 to be forward biased. Forward biasing CR822 will provide a ground state at the anode side, thus allowing only LOAD A(C823) to be present.

CR822 is forward biased by having a supply voltage present at the AD_SW line. When the A_D line is pulled down, Q505 is switched on, forcing the base of Q821 low. PNP transistor Q821 will then be switched on, allowing the output(AD_SW) to be pulled high from SW_QMOD_KEY.

In digital mode, CR821 is not forward biased, thus having CR821 in an open state. During this state LOAD A and LOAD B are used for the PA load. To have CR822 in an open state, AD_SW is not pulled high by SW_QMOD_KEY. The AD_SW state is determined by the A_D line. Having a high state at A_D would switch Q505 off, thus not switching Q821 on.

When a high PA supply voltage is present, the PA may begin dissipating more heat. This may cause overheating to the Call Processor(U1000). The protect the U1000 from overheating, power is reduced by switching in LOAD C and LOAD D. Under normal voltage supplies LOAD C is used and LOAD D is bypassed by forward biasing CR821. When CR821 is forward biased, the anode side is in a ground state. This will not allow LOAD C to be used.

CR821 is forward biased by suppling a voltage at HI_BAT_SW. HI_BAT_SW is controlled by the LOAD_SW line. When HI_BAT_SW is pulled low, PNP transistor Q820 is switched on, allowing HI_BAT_SW to be supplied by SW_QMOD_KEY.

When LOAD C and LOAD D are used CR821 is not forward biased or in an open state condition. To bring CR821 in an open state condition HI_BAT_SW is not supplied. LOAD_SW is pulled high causing Q820 to be switched off, thus not allowing HI_BAT_SW to be supplied by SW_QMOD_KEY.

TDMA StarTAC™ P8190: Analog/Digital Switch

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Channel: 333
TX Freq: 834.99MHz

RX SIGNAL

VOLTAGE SUPPLIES

Colored boxes represent the area in which the components are placed.

A21

U1800-14 page B23 — A_D (A)

U1800-13 page B23 — LOAD_SW (B)

Q1501 page B27 — SW_QMOD_KEY (C)

C826, C825, Q820 (D), Q505 (E), C828, C827, Q821 (F), R821, C821, L821, CR821, CR822, R822, L822, L450

SW_QMOD_KEY — Q1501 page B27

FL450 page B3 — TX_800

20.5 dBm
834.99MHz

C460, C813, L813, R813, C812, C824, C823, C822, C811

TX_800 — U801 page B17

20 dBm
834.99MHz

	Analog	Digital
A	2.82V	0V
E	0V	1.4V
F	2.68V	0V

B+ Voltage level	<4.6V	>4.6V
B	2.7V	0V
D	-1.89V	2.68V

TX	On	Off
C	2.75V	0V

TDMA StarTAC™ P8190: DCI(U1800)

BLOCK DIAGRAM NOT NECESSARY
REFER TO PAGE B21

Description

The DCI(U1800) is data converter interface between the DSP and the RF functions of a dual band TDMA transceiver. It incorporates the following functions:

- Dual channel forward data I and Q(RX_I & RX_Q)
- Two DACs for reverse data I and Q(TX_I & tx_Q)
- DAC for AFC
- DAC for AGC & DAC for reverse PA control
- DAC for PA bias
- Serial Synchronous Interface(SSI)
- Serial Peripheral Interface(SPI)
- Countdown timer for call processor wake-up
- Free-running Real Time Counter to keep track of the time when control processor is stopped
- Internally generates clocks from single master input
- Power saving power-down modes
- Analog wide band forward data signalling functions with SPI interface
- Analog modulator interface
- Analog discriminator interfaces
- RF Discontinuous Receive during Manchester decoding
- On chip voltage reference for transmit I and Q

TDMA StarTAC™ P8190: DCI(U1800)

	TX On	TX Off
D	.081V	3.53V
I	0V	2.79V

Power Step	2	3	4	5	6	7
B	1.7V	1.39V	1.16V	.98V	.86V	.77V
C	.946V	.66V	.46V	.321V	1.18V	.806V
E	2.8V	2.76V	2.75V	2.75V	.055V	.054V
H	.112V	.095V	.083V	.078V	.076V	.075V

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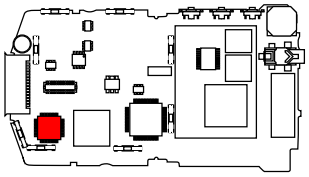
Channel: 385
RX SIGNAL
TX SIGNAL
VOLTAGE SUPPLIES
Colored boxes represent the area in which the components are placed.



B+ Supply	<4.6V	>4.6V
G	2.7V	0V

Sleep Mode	On	Off
K	2.7V	0V

RX On	RX Off
2.7V	0V

Analog	Digital
2.82V	0V

RX Input	-20	-80	-116
A	2.36V	1.43V	.39V

A23

Q505 page B21
R403 page B13
Q811 page B15
A_D (F)
U110 page B7
Q15 page B5
1.12V
Q1831 page B5
BATT_SAV (K)
Q501,Q503 page B19
TX_STEP (E)
R1831 page B5
FE_EN (J)
Q1501 page B27
QMOD_KEY (I)
U1700-60 page B35
TX_EN_B (D)
TX_2.75 page B25
2.76V
U1900 page B37
INTEG_EN
Q1802
0V
R10014
C1801
C1802
R1801
R1806
C132
R1811
R1810
(C) RF_DET
CR502 page B19
U110 page B7
DEMOD
1Vpp
1.36V
U110 page B7
ZIF_SYN_VREF
U110 page B7
RX_I
U110 page B7
RX_Q
520mVpp

R1820
C1803
0.6Vpp
19.44MHz

U1800
3V DCI
AOC_MON

R1800
C1800
2.73V
R1804
RX Input
REF_2.75V page B25
(A) AGC_RSSI
U110 page B7
(B) AOC_CNTL
R342 page B13
1.36V
AFC
U150 page B33

(G) LOAD_SW
Q820 page B21
SS1
U1000 page B39
CLK
U1000 page B39
MOSI
U1000 page B39
MISO
U1000 page B39
IRQ
U1000 page B39
TX
U1900 page B37
RX
U1900 page B37
FS
U1900 page B37
SCLK
U1900 page B37
RESET
U1000 page B39
2.76V
C1805
2.75V
RX_2.75V page B25
2.77V
2.75V page B25
C1804
450mVpp
TX_Q
U301 page B13
TX_QX
U301 page B13
1.4Vpp@10kHz
FM
C306 page B11
450mVpp
TX_I
U301 page B13
TX_IX
U301 page B13
(H) AGC_STEP
U110 page B7

TDMA StarTAC™ P8190: GCAP2(U1500)

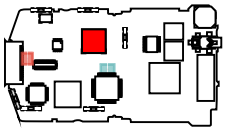
BLOCK DIAGRAM NOT NECESSARY
REFER TO PAGE B25

Description

The GCAP2(U1500) provides the regulators and start-up functions for the entire radio. The GCAP2 contains the following hardware blocks:

- On/Off control signals to properly activate the radio.
- Bandgap reference voltage
- Audio amplification for the speaker
- Audio amplification for the alert
- Audio amplification for the EXT speaker
- Audio amplification of the microphone
- Audio CODEC
- Op-amps for use in the battery charger
- Internal D/A for the battery charger
- 8 channel, 8 bit A/D
- Real Time Clock
- Linear regulators
  - RX_2.75V for RX circuits
  - 2.75V for logic circuits
  - TX_2.75V for TX circuits
  - 5V for negative regulator
  - REF_2.75V for negative regulator reference
- 3 wire bus A/D
- Battery selection control circuitry

TDMA StarTAC™ P8190: GCAP2(U1500)



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A25

R1524 page B27 MIC-
R1580 page B27 MIC+
C1513 page B27 MIC_OUT
DRIVER_B+ page B27 PA_SENSE
Q1501 page B27 PA_DRV
C1530
C1531
2.24V
MIC_BIAS
C1516 page B27 AUX_MIC
C1514 page B27 AUX_OUT
1.31V
VAG
2.77V
2.75V
C1533 page B27 EXT_MIC
1.34V
1.44V
C1545
C1541
C1540
C1542
R1550
C1518
1.38V
L1550
C1538
C1537
R1553
1.37V
R1536
R1554
R1539
C1525
C1527
BOOM_SPKR
J650-3 page B45 EAR-
JFLEX-8 page B47 EAR+
1.38V
JFLEX-7 page B47
SRAM_VCC
U1000 page B39 RAM_CS0
U1300 page B41 SRAM_S1
R730 page B47 KEY_ON*_OFF
U1000 page B39 WDI
R1566 page B29 ISENSE
Q1561 page B29 CHRGC
J3-9 page B47 ON2*
2.94V
R1538

MBCAP
CD_CAP
CONV_BYP
SPKRIN
SPKR_OUT
MOBPORTB

U1500
GCAP2

R1590
3Vpp
32kHz
19.44MHZ
ALRTOUT
EXTOUT
RESET
AGC_RSSI
3WB_RTN
CMP_LVL
MAN_LVL
MAIN_THERM
AUX_THERM

U1000 page B39
C153 page B31
R1555 page B45
R1535 page B27
U1000 page B39
U110 page B7
U1000 page B39
R1005 page B39
R1011 page B37
R1518 page B27
R1517 page B27

C1504
C1507
2.5V
C1508
SPI_BUS
R1514
C1506
R1513
5V
C1505
CODEC_BUS
R1512
C1502
0.5V

RTC_BATT+ page B47
TX_2.75
U1000 page B39
2.75V
RX_2.75V
5V
U1900 page B37

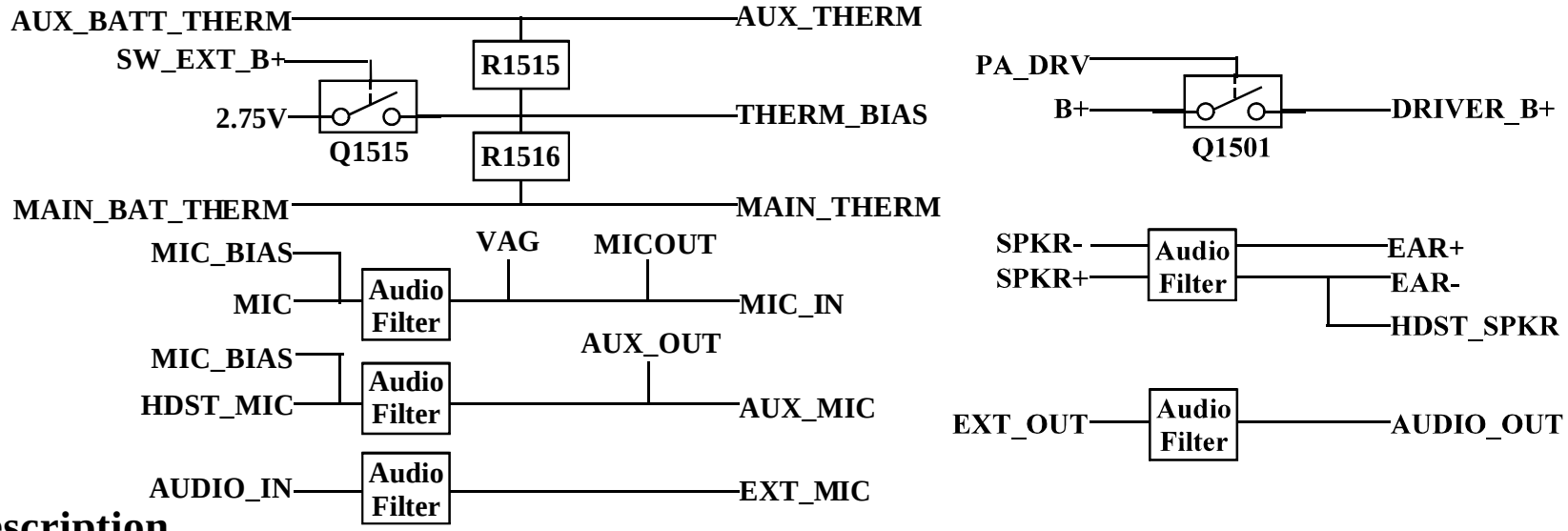
Y1500
32.768kHz

C1503
0.8V
C1551
R1565
C18861
R1561
C1570

B+ page B29
VDOUB page B31
3.75V
SW_EXT_B+ page B43
2.7V
REF_2.75V
MAIN_BATT+ page B47
AUX_BATT+ page B47

MAIN_CTL
Q1572 page B29
AUX_CTL
Q1571 page B29

TDMA StarTAC™ P8190: Audio/Thermistor



Description

The cellular transceiver has the capability to support two batteries, a main battery and an auxiliary battery. Since a charger circuit is designed in this unit, there needs to be a form of reading the thermistor values of each battery separately. The thermistor reading are used to determine the temperature of the battery cell which is being charged.

In order for the call processor(U1000) to read the thermistor values of the batteries, a voltage needs to be placed across the thermistor. As the temperature increases the thermistor will decrease in resistance, causing the supply level at the thermistor to decrease. The thermistor line is pulled high by the THERM_BIAS line. The THERM_BIAS line is sourced from the 2.75V supply through Q1515. Q1515 is switched on only when SW_EXT_B+ is present. If SW_EXT_B+ is not present, Q1515 will be turned off, not allowing THERM_BIAS to be sourced by 2.75V.

The DRIVER_B+ is used to supply drive the exciter circuits for the 800MHz and 1900MHz bands. Driver B+ is sourced from the B+ supply. Q1501 is used as a voltage clamping circuit prevent a voltage level higher than 3.4V from entering the PA driver stage.

In order for the MIC and HDST_MIC circuit to operate a biasing voltage needs to be provided. For this reason, MIC_BIAS is used. The AUDIO_IN circuit doesn't need to have a biasing voltage because the signal entering this line is generated by an external audio generator. All three mic circuits go through an audio filter before entering the CODEC, which is internal to the GCAP2(U1500).

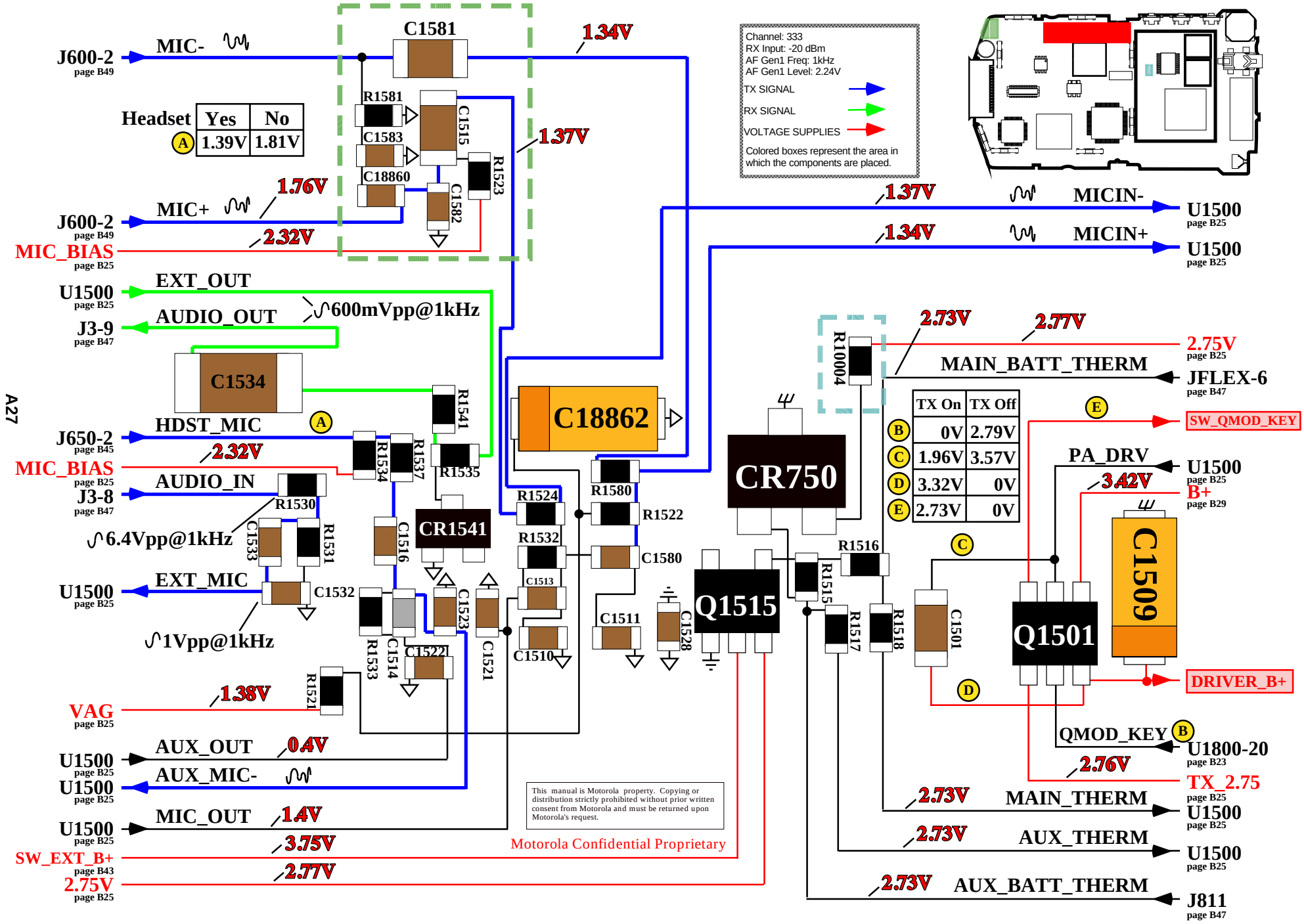
The transceiver supports three audio output ports; ear speaker(EAR-), headset speaker(HDST_SPKR), and external audio port(AUDIO_OUT). The audio path routing is controlled by the GCAP2. The call processor(U1000) programs the GCAP2 to route the audio to its proper path.

When the transceiver determines that audio needs to be routed externally, the other two audio ports are disabled by the GCAP2(U1500). The audio comes from the EXT_OUT line and passes through an audio filter before being sent to the external connector. Because the AUDIO_OUT line has two multiplexed functions, the audio filter also acts as an isolator to the ON/OFF function which in the same line.

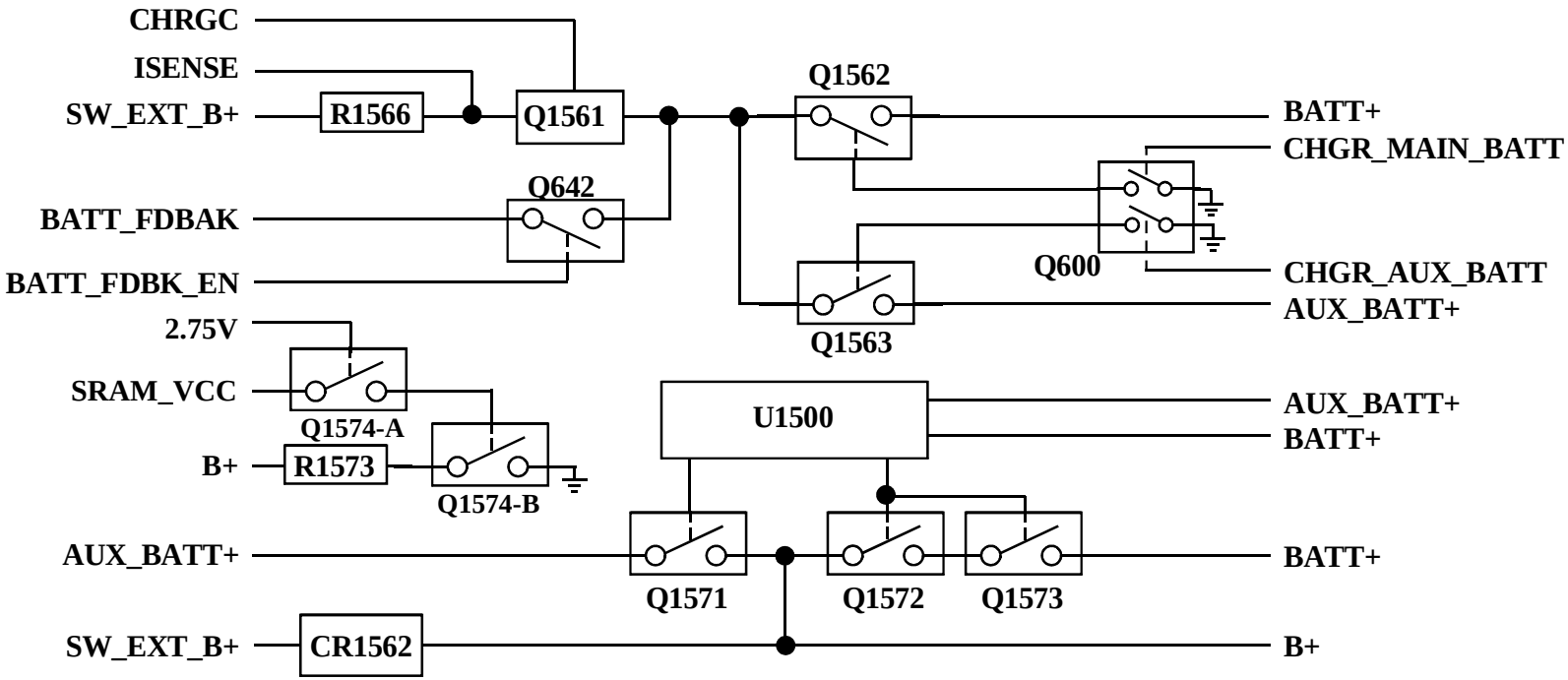
When the ear speaker is used, the EAR- and EAR+ lines are used . The audio signals between EAR+ and EAR- is 180° out of phase. This allows proper operation of the ear speaker.

When a headset is attached to the transceiver, a headset detect interrupt will have the audio only go to the headset speaker(HDST_SPKR). Since the same EAR- line is used for the headset and the ear speaker, the ear speaker is disabled by inverting the EAR- signal 180°. This will present two signals to the ear speaker that have no phase shift, thus, not allowing the ear speaker from functioning.

TDMA StarTAC™ P8190: Audio/Thermistor



TDMA StarTAC™ P8190: Charger/Batt Select



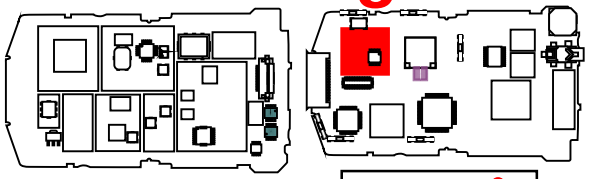
Description

The internal charger will be activated only when there is an external power source, a Motorola battery is attached, the MAN_TEST line is loaded down, and BATT_FDBK is enabled. As SW_EXT_B+ passes thru R1566, U1500(GCAP) reads the charge current for proper control of the charger. CHRGC controls the rate of charge to the batteries by varying the gate biasing of Q1561. The output of Q1561 is split into two different sections. The one section is the BATT_FDBAK line. BATT_FDBK_EN switches Q642 on or off to disable or enable BATT_FDBAK. When BATT_FDBK is not available, the external supply will lower it's supply to a normal operating voltage and the internal charger will be turned. The second section is the line to charge the batteries. The radio is capable of charging two batteries(Main and Auxiliary). The phone is designed to always charge the main battery first. Once the main battery is fully charged, it will begin charging the auxiliary battery. Lines CHGR_MAIN_BATT and CHGR_AUX_BATT selects which battery will be charged. The dual transistor package Q600 has its outputs controlled by CHGR_MAIN_BATT and CHGR_AUX_BATT. Each line out put of Q600 turns on or off charge transistors Q1562 and Q1563. When Q1562 is turned on, the main battery will be charged. When Q1563 is turned on, the auxiliary battery will be charged.

U1570(ABC) is used to select the B+ supply source of the radio. SW_EXT_B+ takes priority over any other source for the B+ power source. During this condition, Q1570, Q1571, Q1572, and Q1573 are turned off, thus, having SW_EXT_B+ supply B+ thru CR1562. AUX_BATT+ is selected for the B+ power source if no SW_EXT_B+ is present. During this condition, Q1572 and Q1573 is turned off and Q1570 and Q1571 is turned on, allowing AUX_BATT+ supply B+. MAIN_BATT+ is selected for the B+ power source if no EXT_B+ or AUX_BATT+ is present(or AUX_BATT+ is below minimum operating voltage). During this condition, Q1572 and Q1573 is turned on and Q1570 and Q1571 is turned off allowing BATT+ supply B+.

In order for power cuts to operate correctly a B+ discharge circuit is required. B+ must discharge below 0.4V in 1 second. When the supply 2.75V is disabled(from a power cut state) Q1574-A is turned on, thus turning on Q1574-B. When Q1574-B is turned on, B+ will be discharged through R1573. If the phone is in an on state, Q1574-A is turned off, thus turning off Q1574-B. During this state B+ will not discharge through R1573.

TDMA StarTAC™ P8190: Charger/Battery Select



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VOLTAGE SUPPLIES

Colored boxes represent the area in which the components are placed.

SW_EXT_B+ 5.69V
page B43

R1565

C18861

U1500 CHRGC (I)
page B25

U1500 ISENSE 5.63V
page B25

R1566

Q1561

Q1562

CR1555

U1700-51 CHRG_MAIN_BATT (E)
page B35

MAIN_BATT+ 3.75V
page B47

A29

U1500 MAIN_CTL
page B25

(A)

Q1573

Q1572

R1564

R1563

C1560

Q600

C1575

CR1561

CR1560

CR1562

Q1571

(D)

Q1563

R1574

R1575

R1573

Q1574

C1571

(J)

0V

2.67V

3.72V

B+ 3.71V

C1564

R643

R642

C1563

Q642

MAIN_BATT+ 3.75V
page B47

AUX_BATT+ 4.11V
page B47

SW_EXT_B+ 5.69V
page B43

B+ 3.71V

(C)

Charge	Main	Aux
(C)	0V	5V
(D)	5.2V	0V
(E)	2.72V	0V
(F)	0V	2.72V

Charger	On	Off
(G)	2.74V	0V
(H)	4.37V	0V
(I)	4.3V	4.51V
(J)	4.03V	0V

MAIN_BATT+ 3.75V
page B47

SRAM_VCC 2.71V
page B25

Battery Source	Main	Aux
(A)	0V	3.61V
(B)	3.71V	0V

B+ 3.71V

AUX_BATT+ 4.11V
page B47

(B) AUX_CTL
U1500
page B25

B+ 3.71V

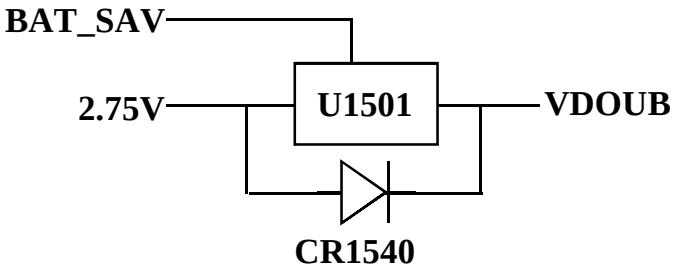
(G) BATT_FDBK_EN
U1700-53
page B35

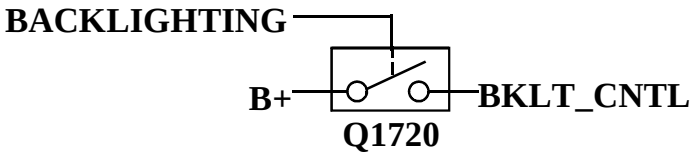
(H) BATT_FDBAK
J3-4
page B47

AUX_BATT+ 4.11V
page B47

(F) CHRG_AUX_BATT
U1700-50
page B35

TDMA StarTAC™ P8190: DOUB Supply/Backlight





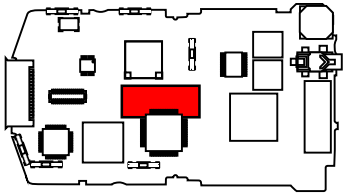
A30

Description

There are some circuits that require a voltage higher than the battery source. For this reason, a voltage doubling charge pump circuit is provided. U1501 takes the 2.75V source and oscillates it with a high peak to peak signal. The positive region of the signal is then sent out to produced the VDOUB supply. When the transceiver is in sleep mode, U1501 is disabled and the VDOUB supply will be the same level as the 2.75V supply.

The display backlighting is controlled by the Call processor(U1000). U1000 sends a control signal via the BACKLIGHTING line. A high state at the BACKLIGHTING line will switch Q1720 on. This will allow B+ to supply the BKLT_CNTL line. As a result, the display backlighting will illuminated.

TDMA StarTAC™ P8190: DOUB Supply/Backlight



VOLTAGE SUPPLIES →

Colored boxes represent the area in which the components are placed.

Sleep Mode	On	Off
C	2.75V	0V
D	2.52V	5.5V

3.4V

B+
page B29

J1B-32
page B47

BKLT_CNTL (A)

Q1720

C1720

R1720

U1000
page B39

BACKLIGHTING (B)

C1722

C1555

U1501

R1830

C1553

C1552

CR1540

2.75V

RX_2.75V
page B25

(C) BATT_SAV

U1800-16
page B23

(D) 5.5V

VDOUB

2.8Vpp@87.7kHz

2.77V

2.75V
page B25

Backlight	On	Off
A	2.8V	0V
B	2.6V	0V

A31

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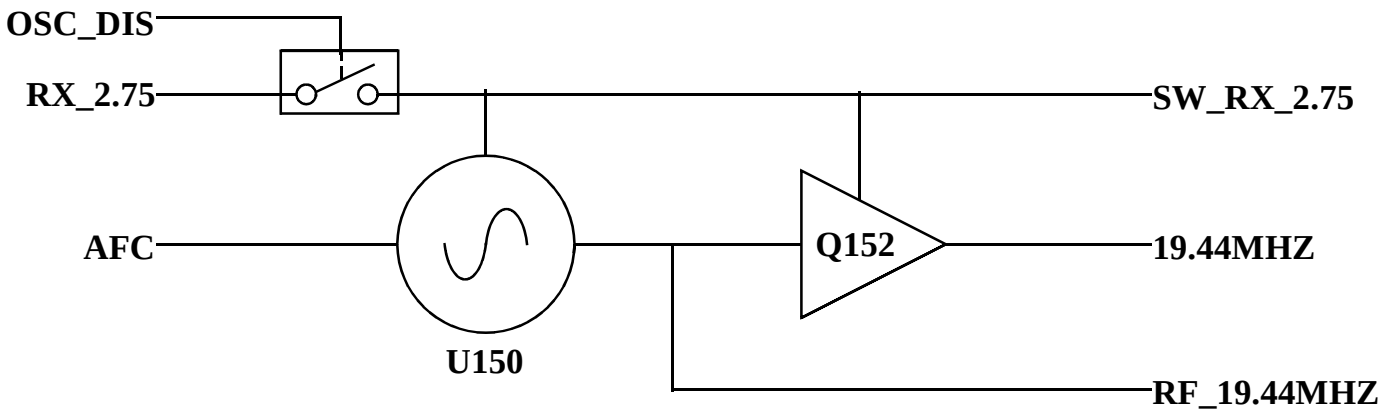
TDMA StarTAC™ P8190: Reference Oscillator



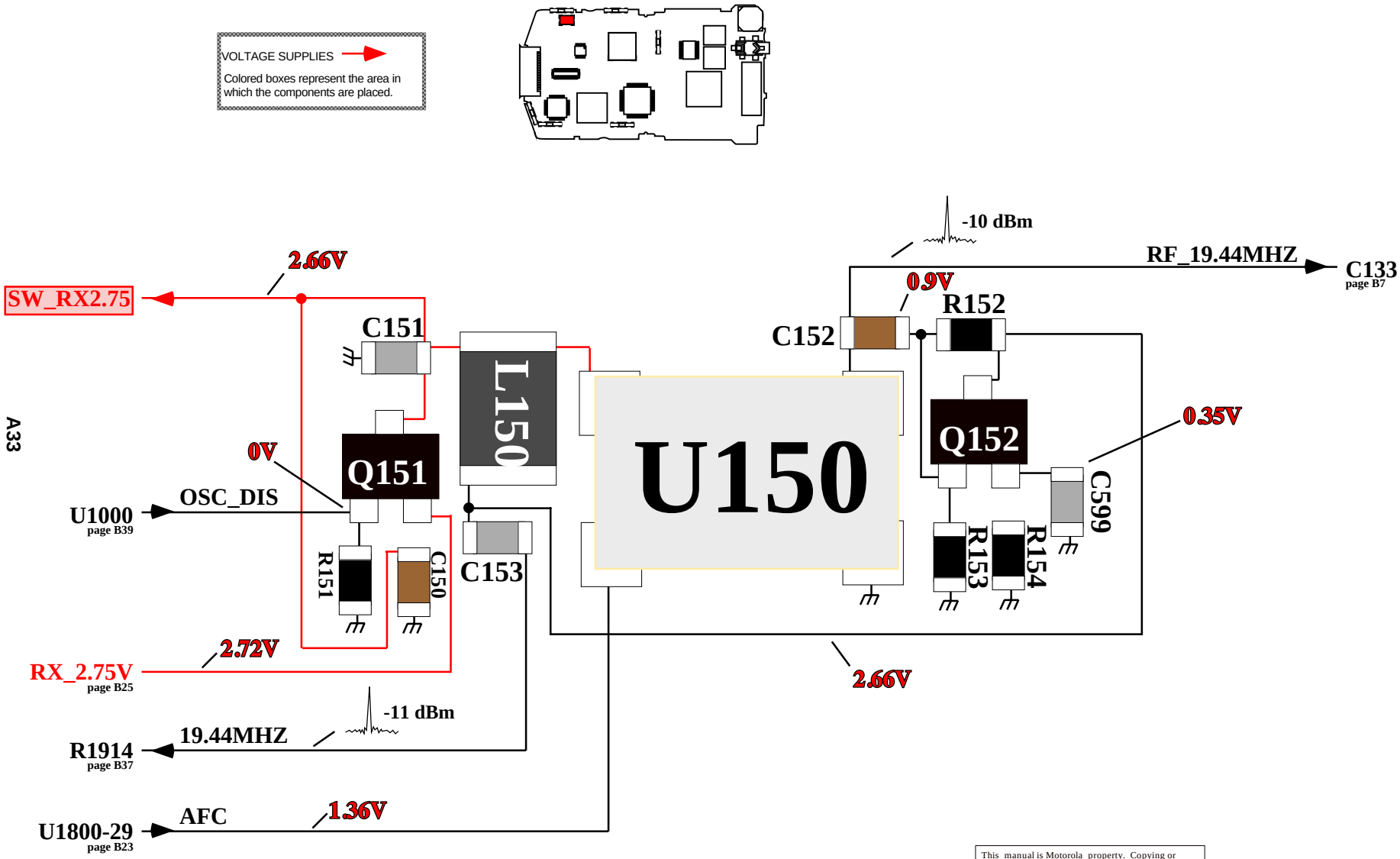
A32

Description

The reference oscillator U150, operating at 19.44MHz, provides a "reference frequency" for the RF synthesizers and various logic circuits. U1000(CPU) switches U150 on and off via the OSC_DIS line. The Osc_DIS line switches Q151 on or off, controlling the supply voltage to U150 and Q152. U1800 can "fine tune" U150 via the AFC line. Tuning of the reference oscillator is needed to synchronize frequencies with the cellular base station, therefore, the signal received from the base will be used to determine the correct reference frequency.

The ouput of U150 is split into two signals. RF19.44MHz is used for the RF frequency reference. Output 19.44MHz is amplified by Q152 and then sent to the logic section for logic clock synchronization.

TDMA StarTAC™ P8190: Reference Oscillator



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TDMA StarTAC™ P8190: STUART(U1700)

BLOCK DIAGRAM NOT NECESSARY
REFER TO PAGE B35

Description

The STUART IC(U1700) is a custom gate array that uses the following functions.

Host Port Emulation - This provides a bus interconnection between the call processor and the DSP via the call processor's parallel memory bus, interconnected to the modem DSP's parallel memory bus. This communications port is functionally identical to the host port provided for the Motorola DSP; To both devices, the port appears as a bus-mapped peripheral. The call processor sees the port as an 8-address block in memory at a location determined by the call processor's programming of its own chip select for the START IC. The DSP sees the port as an 8-address block in I/O space. Because the STUART IC uses the high byte of the DSP's bus, provisions are made for byte/word conversion, to be compatible with the existing word-wide communications with U1000(Call processor).

DSP Timer - It provides a timer function. This is a device, accessible to the DSP, which implement a continuously clocked timer, with rollover, a feature needed for modem functionality but difficult to implement with the ATT device. The ATT timer can be set up to either stop on count=0, or to repeat the last count interval. We need a counter that can be set up to interrupt at a particular point in time, and then keeps counting, so that real-time is preserved, and can be set for a future time interval. This timer has a clock that is coherent with the symbol rate.

General Purpose I/O - It provides a 4-bit general purpose I/O port, with programming data direction function, as an extension to the call processor bit I/O set.

RF SPI interface - Improved interface between the Call processor, DSP, and ZIFSYN for scanning requirements needed because of the PCS band

Transmitter control logic - Transmitter keying and frequency band selection.

TDMA StarTAC™ P8190: STUART(U1700)

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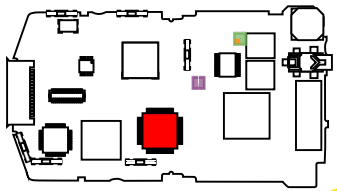


A35

U1000 page B39 — CALL_ADD

U1000 page B39 — RWB

U1000 page B39 — ECLK — 4.2Vpp

U1000 page B39 — HOST_ENB — 2.76V

U1000 page B39 — RESET — 2.78V

2.77V

2.75V page B25

-10 dBm

19.44MHZ — C18853

C153 page B31

C1702

R1708

U1900 page B37 — GP_INT

U1900 page B37 — RWN

U1900 page B37 — IO

U1900 page B37 — MODEM_ADDR

U1900 page B37 — MODEM_DATA

2.77V

2.75V page B25

C1700

C1701

U1700
STUART

Q1803

Q1804

A — 800KEY — CR810 page B15

C — 1900KEY — CR910 page B15

CALL_DATA — U1000 page B39

2.77V

2.75V page B25

E — 800*_1900 — U301,U700

F — 800_1900* — R15 page B5

B

D

G — TX_EN_B — U1800-21 page B23

RDB — U1200,U1300 page B41

ZIFSYN_EN — U110 page B7

RF_DATA — U110 page B7

RF_CLK — U110 page B7

IRQ — U1000 page B39

J — BATT_FDBK_EN — Q642 page B29

I — CHRG_MAIN_BATT — Q600-5 page B29

H — CHRG_AUX_BATT — Q600-2 page B29

FS — U1900 page B37

R1711

K — VIB_ON — Q1710 page B9

R1713

VOLTAGE SUPPLIES →
Colored boxes represent the area in which the components are placed.

Vibrator	On	Off
J	1.86V	0V

TX	On	Off
G	0V	3.53V

Charger	On	Off
J	2.74V	0V

Charge	Main	Aux
I	2.72V	0V
H	0V	2.72V

TX Band	800	1900
A	0V	3.93V
B	0.95V	0V
C	3.36V	2.77V
D	0V	0.96V
E	0V	2.8V
F	2.7V	0V

TDMA StarTAC™ P8190: DSP(U1900)

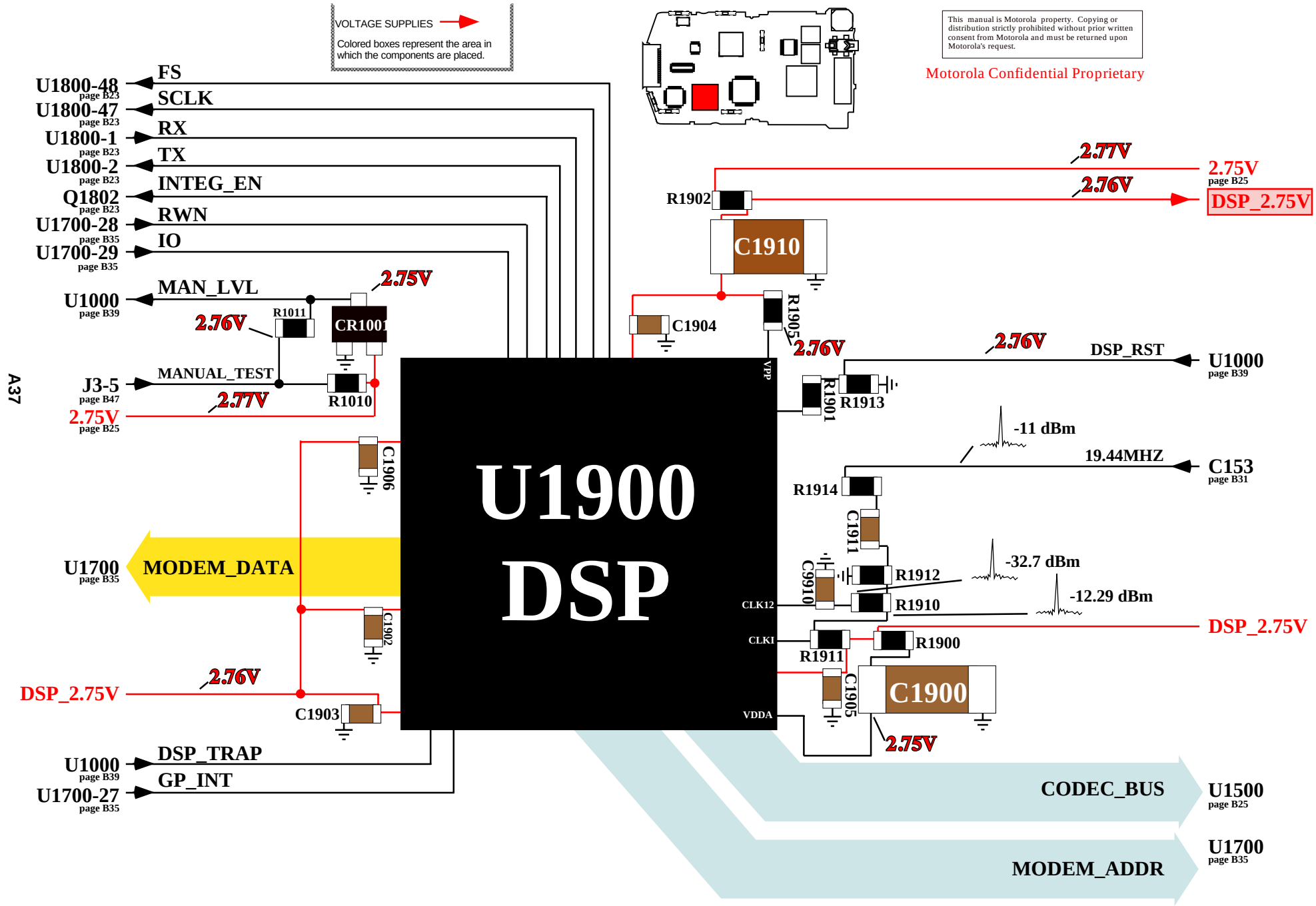
BLOCK DIAGRAM NOT NECESSARY
REFER TO PAGE B37

Description

The following list is a description of the DSP(U1900):

- ROM Mask Device(48K)
- Patch RAM space(16K)
- Fixed point MAC(multiply accumulator)
- 8-bit parallel interface
- 8-bit control I/O interface
- Dual serial I/O ports
- Two external interrupts
- Flexible power management including Sleep mode, Sleep with slow internal clock, and stop
- Three modes of operation
  1. Actively running
  2. Light sleep - Clocks running, but lower power consumption
  3. Deep sleep - All clocks off, extremely low power consumption
- Digital Traffic Channel
  1. Acquiring and maintaining synchronization with the Digital Channel
  2. AFC, AGC, AOC control loops
  3. Vocoders (ACELP and VCELP)
  4. Channel equalization
  5. Channel decoding
  6. Channel encoding
  7. Audio functions
  8. MAHO measurements
- Digital Control channel
  1. Essentially DTC minus audio and vocoders
  2. ROCM instead of MAHO
  3. Modem goes into deep sleep for long periods
- Analog Control Channel
  1. No RX functions - modem in deep sleep
  2. Manchester Encoder
  3. Transmitter control
- Analog voice channel
  1. Audio processing
  2. SAT detection/Transponding

TDMA StarTAC™ P8190: DSP(U1900)



TDMA StarTAC™ P8190: Call Processor(U1000)

BLOCK DIAGRAM NOT NECESSARY
REFER TO PAGE B39

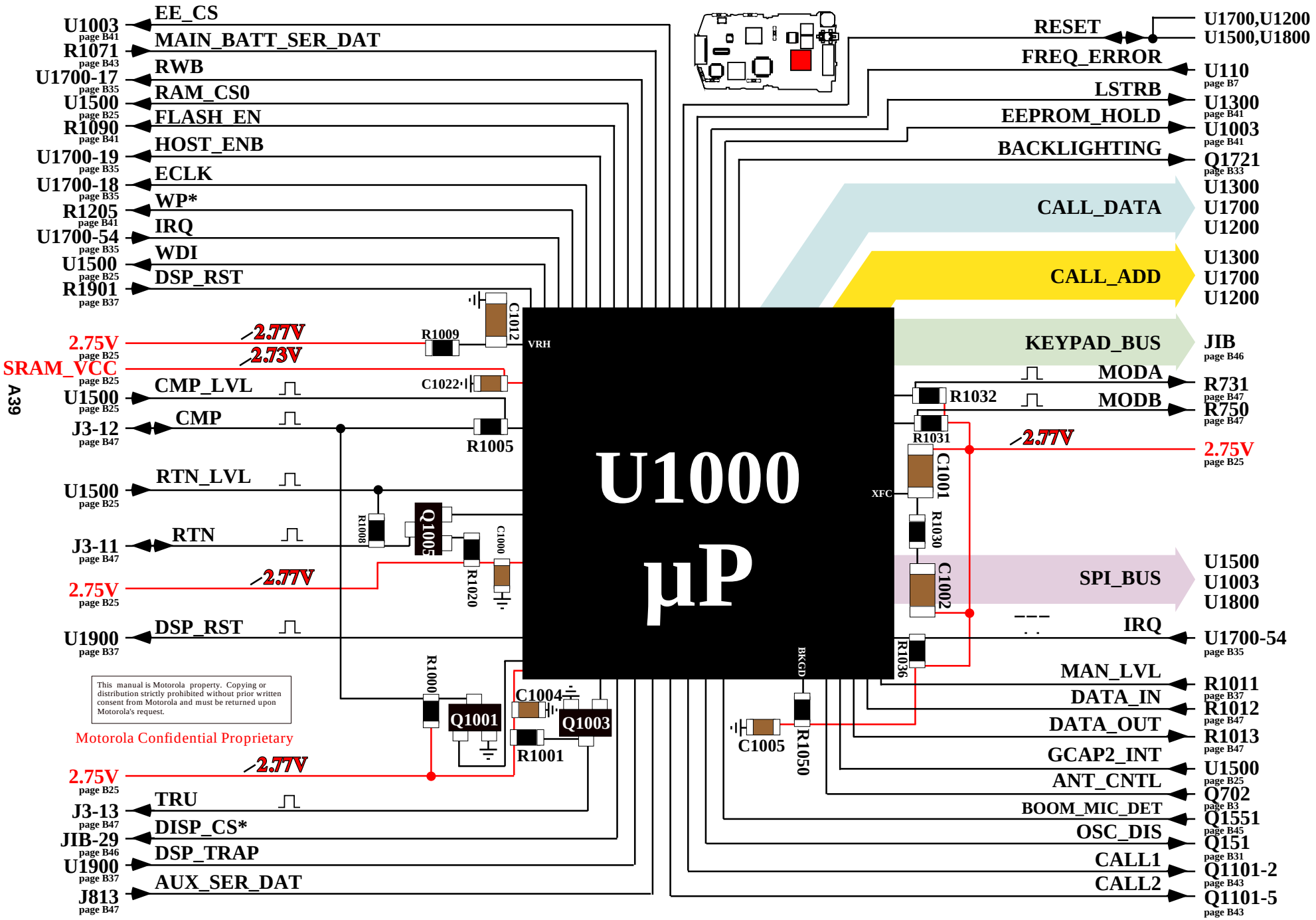
Description

U1000 is a single-chip microcontroller that controls major functions of the cellular phone. U1000 will perform the functions of both the master controller and keyboard processor. These functions include:

- Keypad interrupt and scanning
- Display driving
- Control of audio and RF hardware
- Call processing (signalling) software
  - ON/OFF control
  - EEPROM access
  - Synthesizer programming
  - Automatic Frequency Control(AFC)
  - Transmit power setting
- User Interface

U1000 is not packaged with internal memories as past Call processors. This means that vital information that was previously stored in the memory of previous call processors is now stored in the external EEPROM(U1003).

TDMA StarTAC™ P8190: CALL PROCESSOR(U1000)



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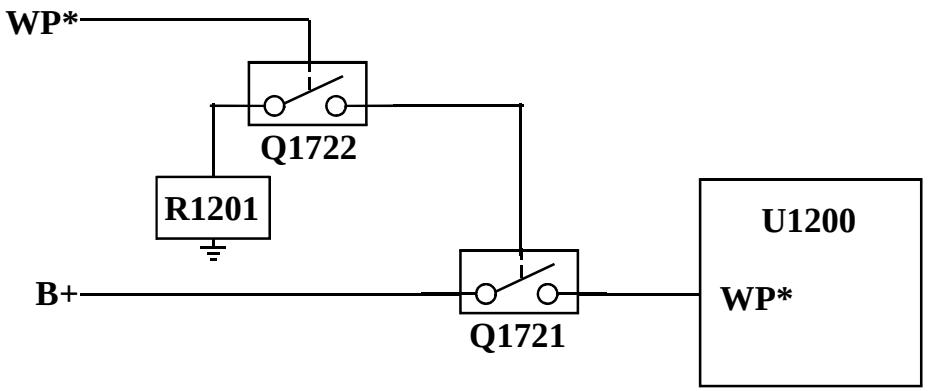
TDMA StarTAC™ P8190: Memory



A40

Description

A serial EEPROM(U1003) of 256K bytes is used for storage of the NAM information, authentication keys, phasing data, ESN, and memory. The EEPROM serial interface to the microcontroller is a standard SPI-compatible interface.

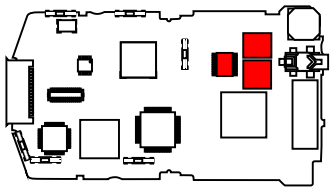
U1300 is a 64K x 16 low voltage, low power SRAM. U1300 uses a parallel interface bus.

U1200 is a 512K x 8 flash EPROM. U1200 uses a parallel interface bus.

The WP* line is used during EPROM flash conditions. When the EPROM is not being flashed, WP* is at a low state. This condition will switch Q1722 off, thus, allowing the gate of Q1721 to be pulled high. A high state at the gate of Q1721 will switch Q1721 off, thus, not allowing WP* from U1200 to be pulled high by B+.

During flashing conditions, WP* is pulled high. This condition will switch Q1722 on, allowing the voltage at the gate of Q1721 to drop. A lower voltage at the gate of Q1721 will switch the transistor on. This condition will allow WP* from U1200 to be pulled high by B+.

TDMA StarTAC™ P8190: MEMORY



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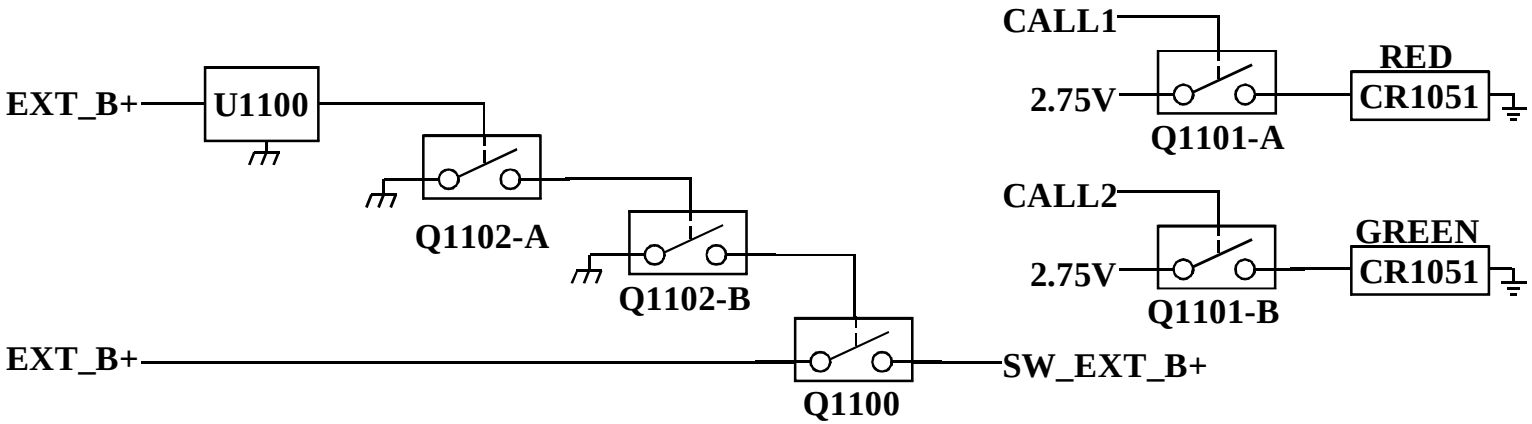
A41

2.77V
2.75V page B25
2.73V
SRAM_VCC page B25
3.42V
B+ page B29
3.42V
0V
U1000 page B39 SPI_BUS
R1200
C1093
2.77V
2.75V page B25
WP*
U1000 page B39
0V
EEPROM_HOLD
U1000 page B39
2.74V
EE_CS
U1000 page B39
Q1721
Q1722
R1203
R1205
R1201
R1204
C1006
C1021
C1200
C1003
C1023
U1003 EEPROM
11 12 13 14 15 16 17 18 19 20
10 9 8 7 6 5 4 3 2 1
U1300 RAM
CS
SRAM_S1 U1500 page B25
CALL_DATA U1000 page B39
CALL_ADD U1000 page B39
RWB U1000 page B39
U1200 EPROM
WP*
CALL_DATA U1000 page B39
CALL_ADD U1000 page B39
RESET U1000 page B39
RWB U1000 page B39
R1090
FLASH_EN U1000 page B39
R1092
2.77V
2.75V page B25

TDMA StarTAC™ P8190: B+ Disconnect/Status LEDs



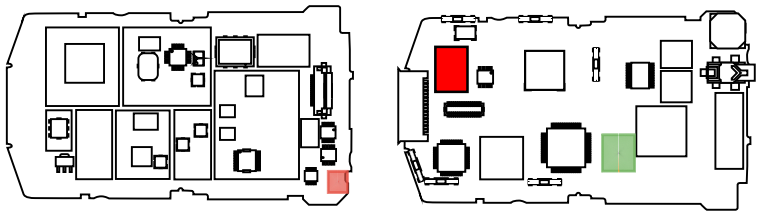
A42

Description

The overvoltage circuit consist of a voltage detector(U1100) and a power switch(Q1100). A resistor divider network at the input of U1100 is used to set the EXT_B+ detect voltage to 6.75V nominal. U1100 outputs low whenever the input voltage is below the detector threshold. During normal operating voltages from EXT_B+ the gate voltage of Q1100 is zero, which turns Q1100 on. When Q1100 is on, SW_EXT_B+ is connected to EXT_B+. When EXT_B+ voltage is above 7.0875V nominally, U1100 output becomes open drain. This causes the gate of Q1100 to be pulled up to the EXT_B+, which turns Q1100 off and thus disconnects the voltage to SW_EXT_B+. Q1102-A and Q1102-B act as inverters. Therefore, a low state at the output od U1100 will result with a low state at the gate of Q1100 and vise versa.

The status LED is controlled by U1000 via CALL1 and CALL2. In order to enable either LED the corresponding Q1101 transistor is enabled, allowing the status LED to be supplied by 2.75V.

TDMA StarTAC™ P8190: B+ Disconnect/Status LEDs



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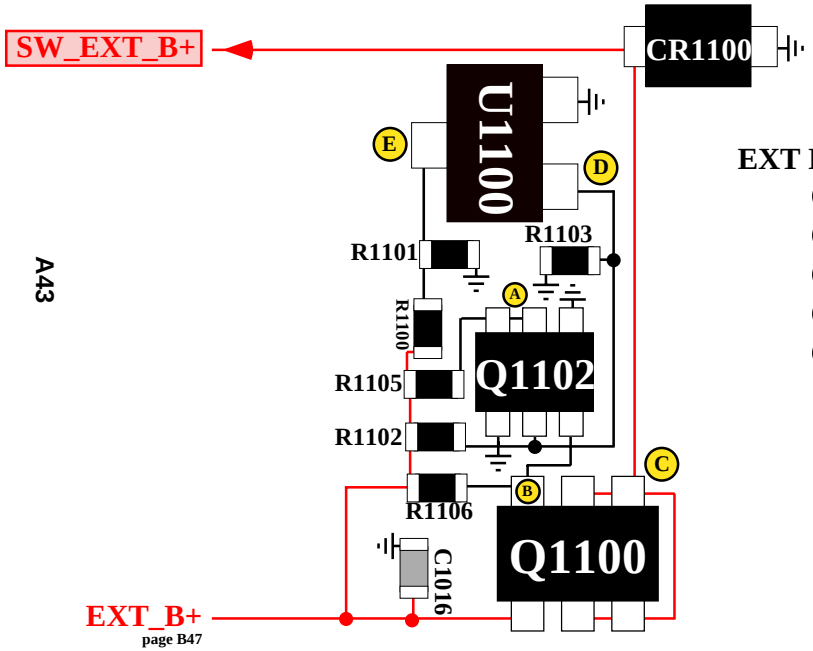
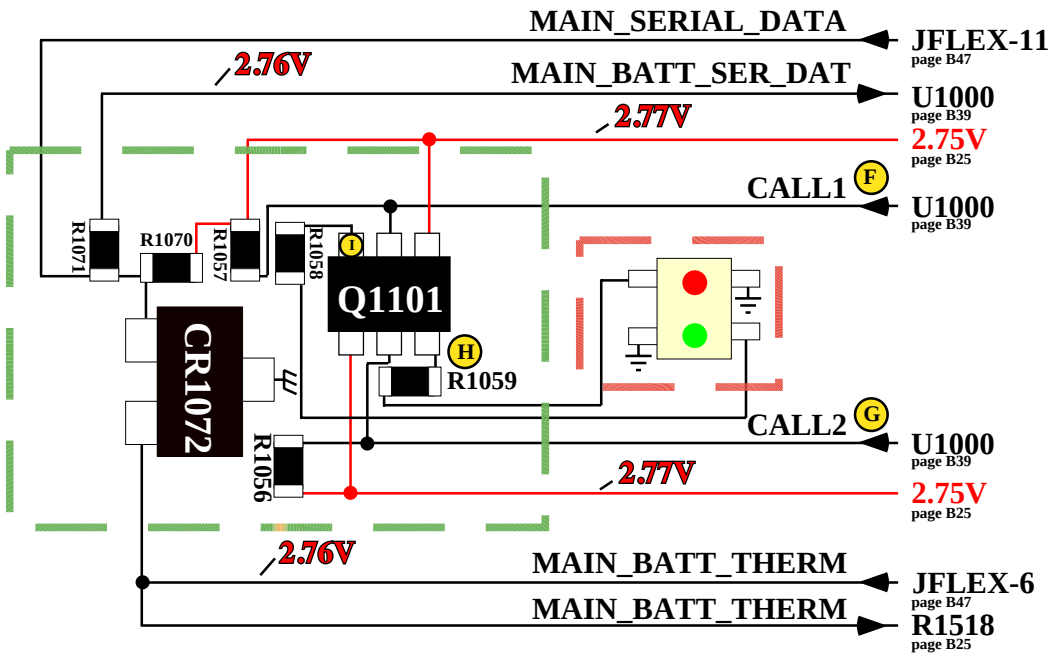


EXT B+	<6.7V	>7.2V
A	1.67V	0V
B	0V	7.29V
C	6.49V	0V
D	0V	2.63V
E	2.59V	2.9V

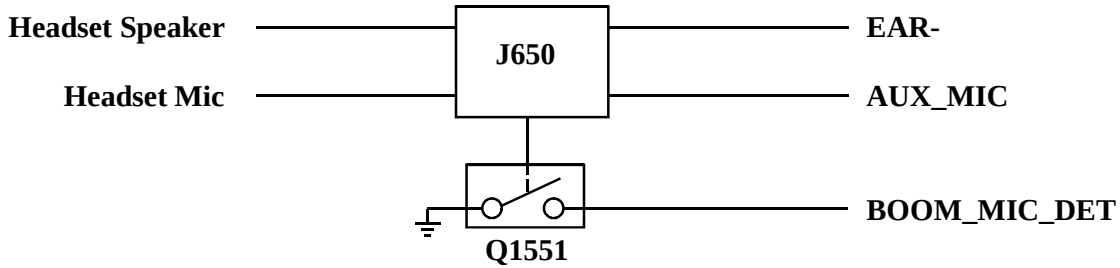


LED	Red	Green
F	2.75V	0V
H	0V	2.75V
G	0V	2.75V
I	2.75V	0V

VOLTAGE SUPPLIES →

Colored boxes represent the area in which the components are placed.

TDMA StarTAC™ P8190: Alert/Headset Detect



A44

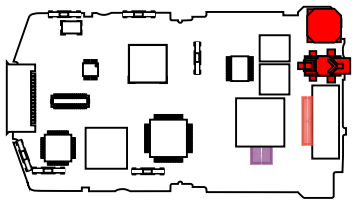
Description

When a headset is inserted in J650, the internal speaker and microphone is disabled. The user can now use the headset for handsfree conversation. BOOM_MIC_DET informs U1000 whether a headset is inserted or not. The state of BOOM_MIC_DET is controlled by Q1551.

When the headset is inserted the biasing voltage for the AUX_MIC will no longer be present at the base of the NPN transistor Q1551. This will switch Q1551 off, thus, allowing BOOM_MIC_DET to be pulled high. When the headset is not inserted, the AUX_MIC biasing voltage is present at the base of Q1551. This condition will switch Q1551 on, thus, pulling the BOMM_MIC_DET to ground.

CR1071 and CR1070 are devices used for ESD protection for its corresponding line.

TDMA StarTAC™ P8190: Alert/Headset Detect



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3.42V

B+
page B27

LS1

3.8Vpp

U1500-48
page B25
ALRTOUT

R1537
page B25
HDST_MIC

VOLTAGE SUPPLIES

Colored boxes represent the area in which the components are placed.

A45

Headset	On	Off
A	0V	1.81V
F	2.75V	0V

C1520

C18858

R1555

VR1500

C1550

1.81V

R1540

Q1551

F

U1000
page B33
BOOM_MIC_DET

2.75V

2.75V
page B25

A

J650

C1519

0.52V

BOOM_SPKR

C1518
page B25

CR1071

1.39V

EAR+

JFLEX-7
page B41

U1500-42
page B25

CR1070

1.37V

EAR-

JFLEX-8
page B41

U1500-41
page B25

TDMA StarTAC™ P8190: JIB Connector

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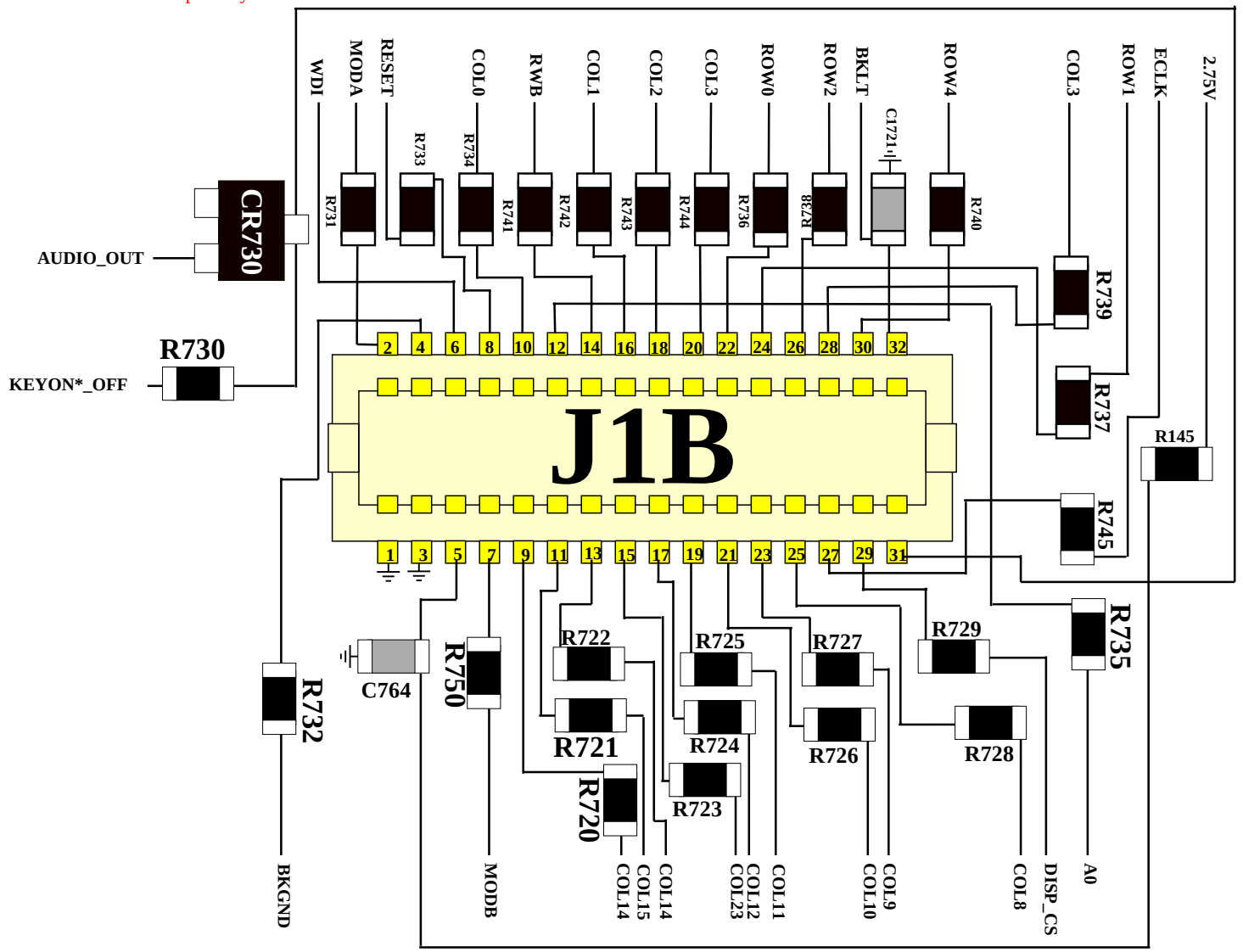

TDMA StarTAC™ P8190: CONNECTORS

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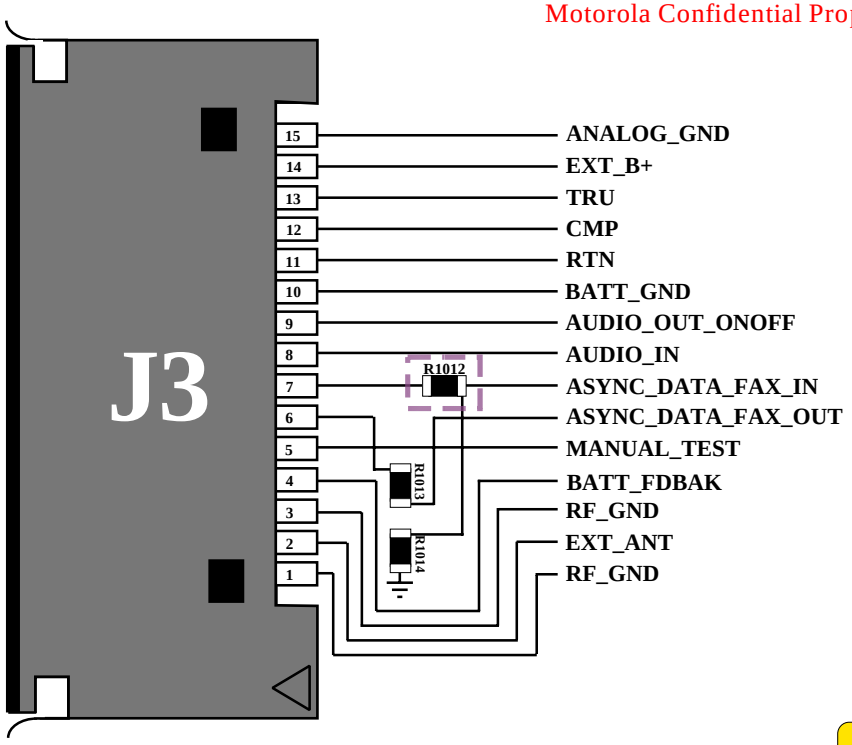
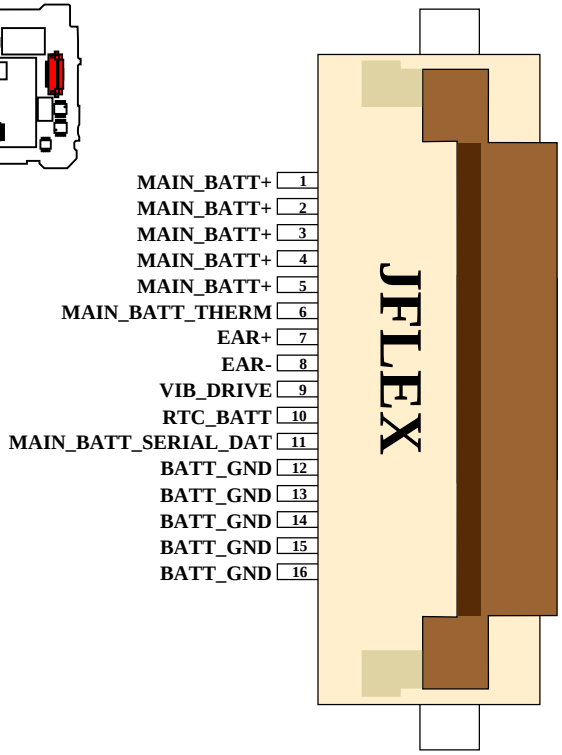




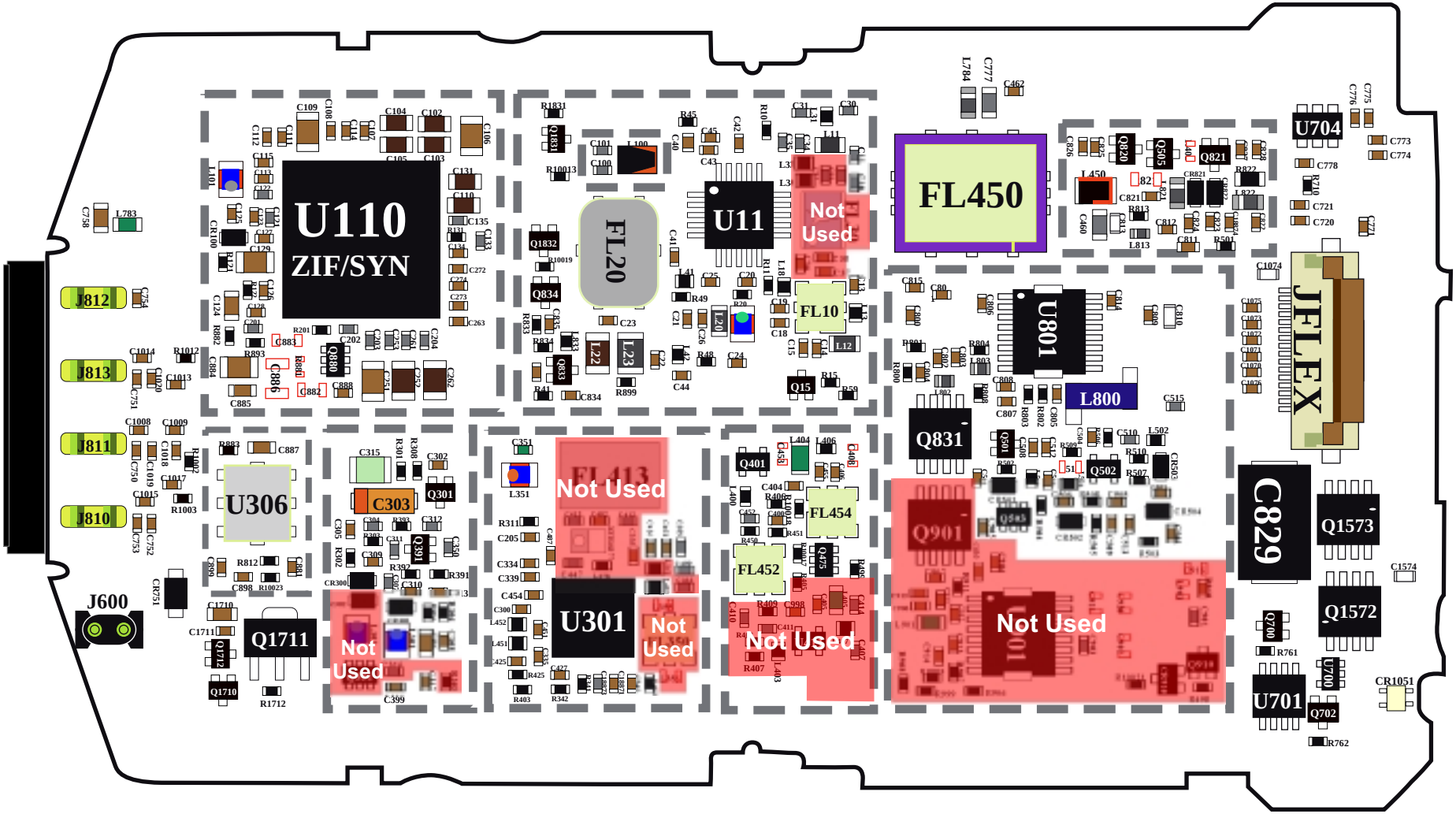
J812 RF_GND

J813 AUX_SERIAL_DATA

J811 AUX_THERMISTOR

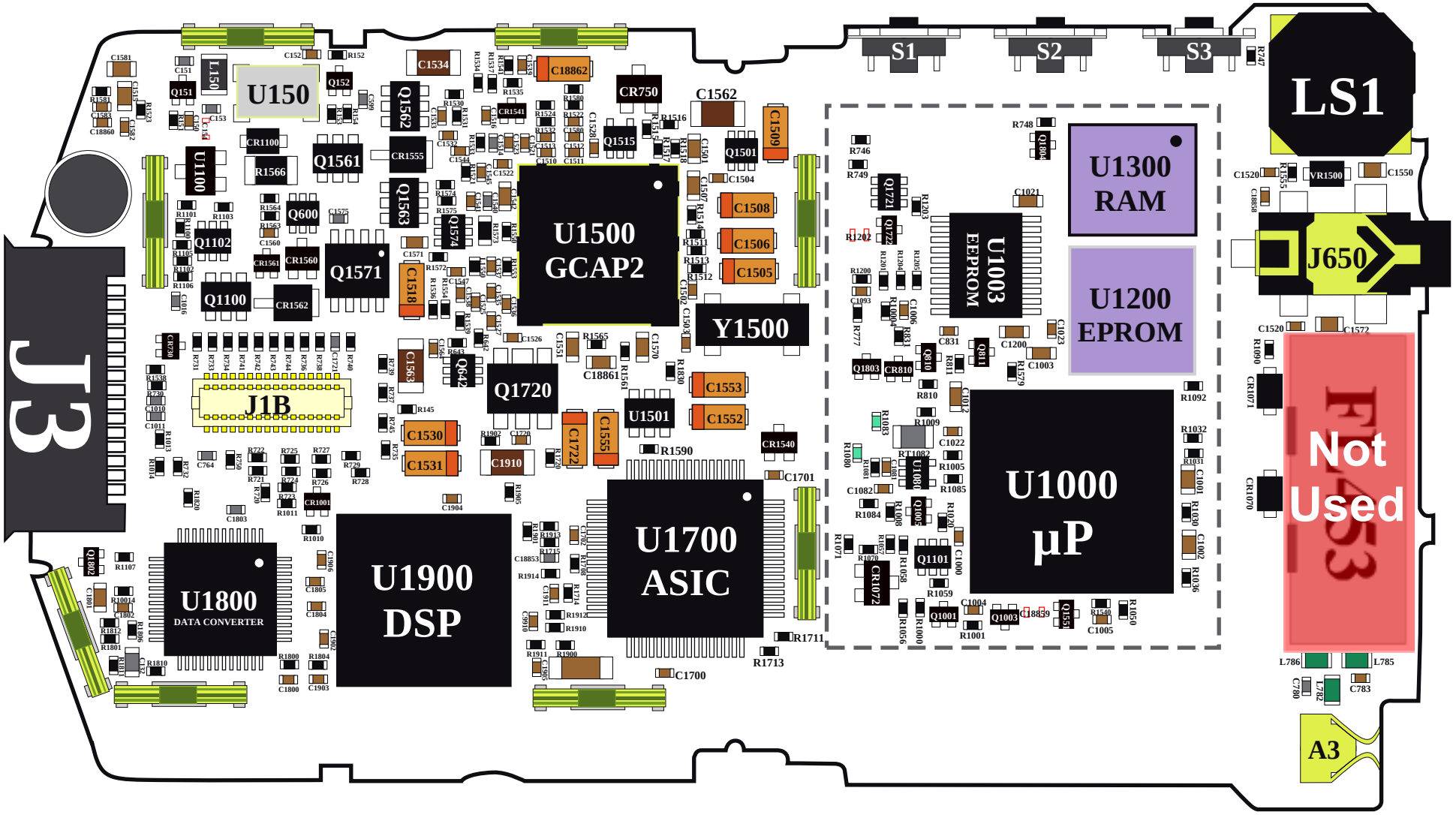
J810 AUX_BATT+

TDMA StarTAC™ P8190: Layout Side 1

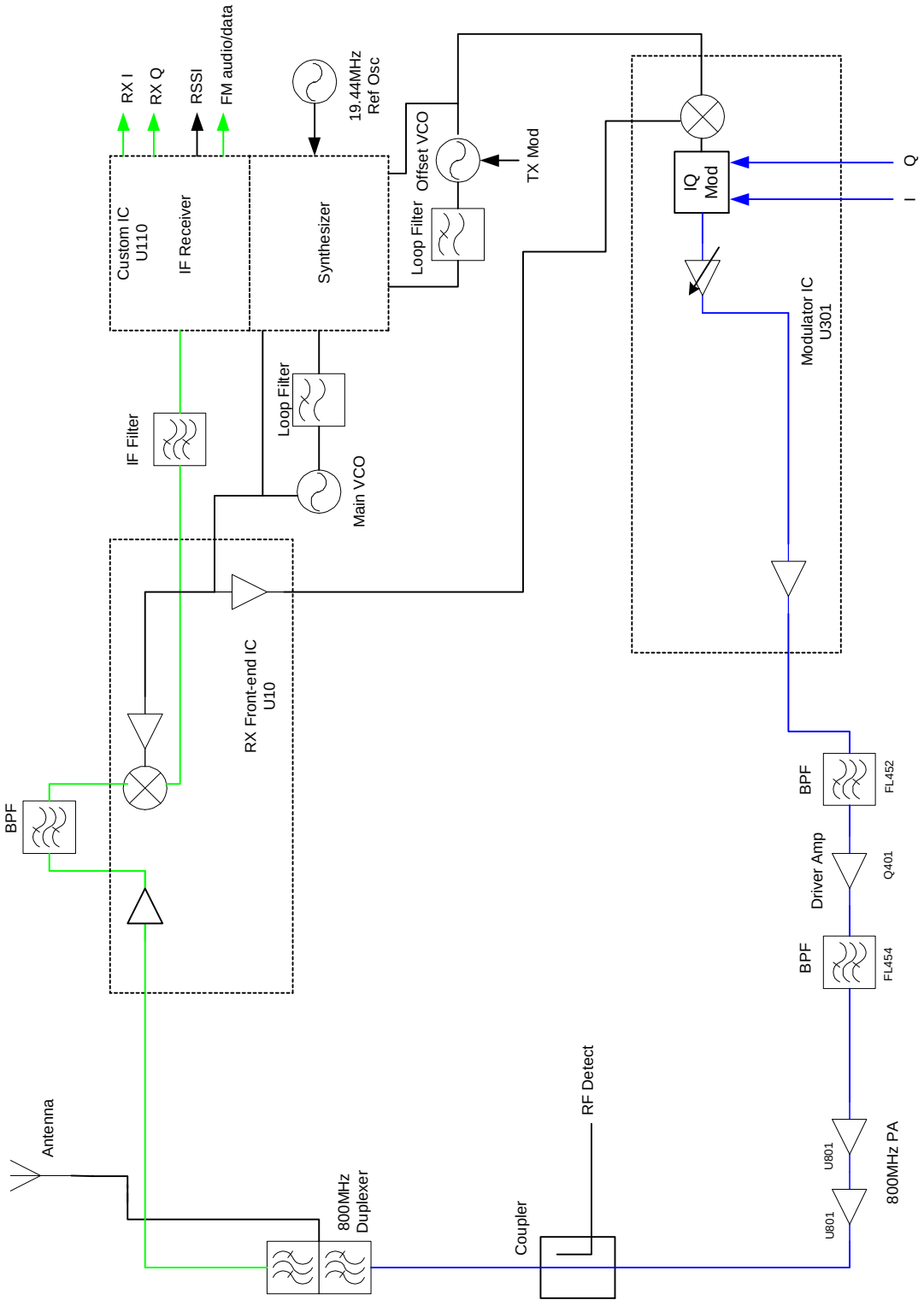


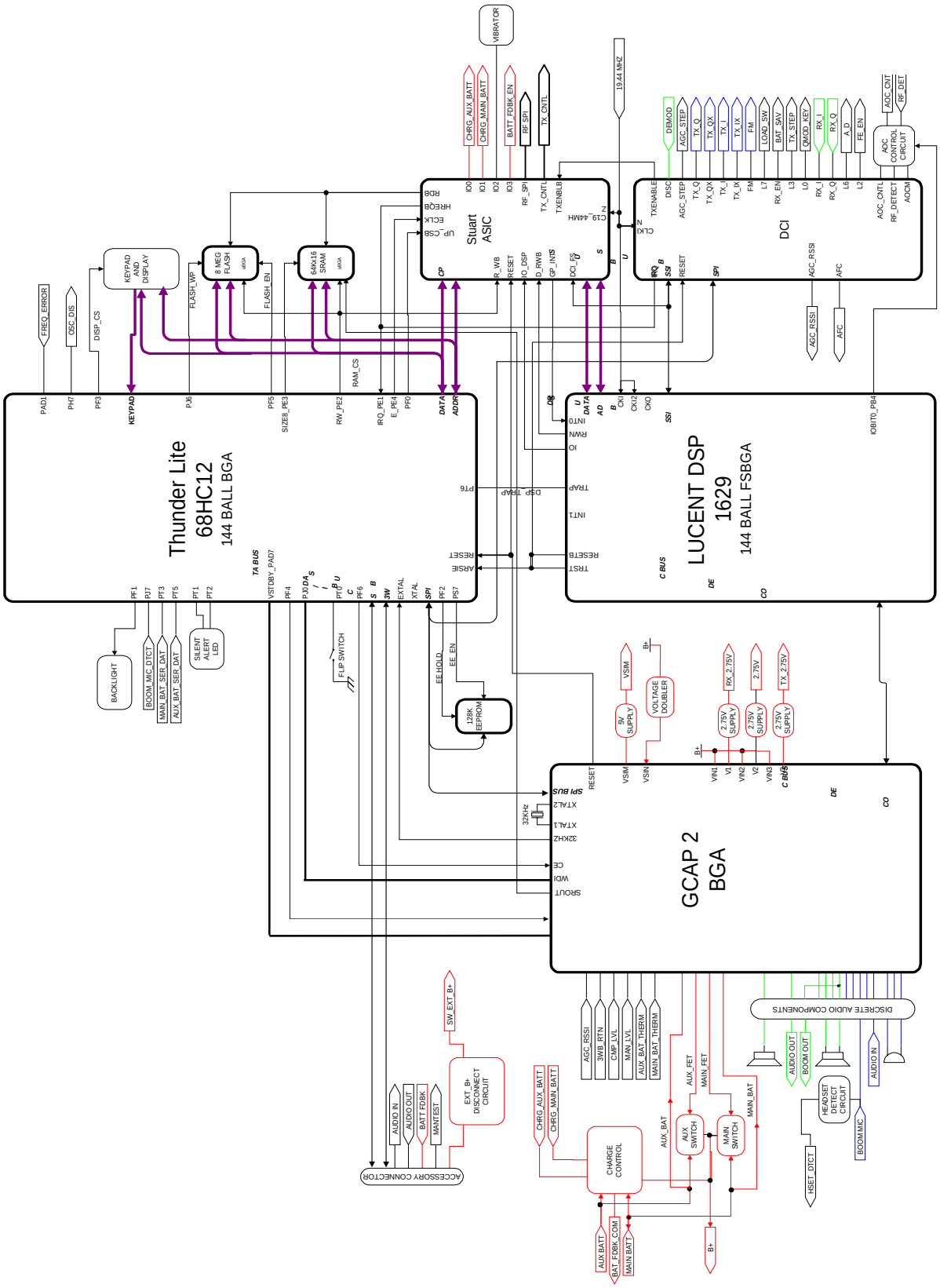
Board Issue: P11

TDMA StarTAC™ P8190: Layout Side 2



Board Issue: P11


RX I
RX Q
RSSI
FM audio/data
19.44MHz
Ref Osc
Offset VCO
TX Mod
Loop Filter
Custom IC
U110
IF Receiver
Synthesizer
IQ
Mod
Q
I
Modulator IC
U301
IF Filter
Loop Filter
Main VCO
RX Front-end IC
U10
BPF
BPF
FL452
Driver Amp
Q401
BPF
FL454
Antenna
800MHz
Duplexer
Coupler
RF Detect
U801
U801
800MHz PA


Thunder Lite
68HC12
144 BALL BGA
LUCENT DSP
1629
144 BALL FSBGA
GCAP 2
BGA
Stuart
ASIC
DCI
KEYPAD AND DISPLAY
8 MEG FLASH
64Kx16 SRAM
128K EEPROM
VIBRATOR
19.44 MHZ
CHRG_AUX_BATT
CHRG_MAIN_BATT
BATT_FDBK_EN
RF_SPI
TX_CNTL
DBMOD
AGC_STEP
TX_Q
TX_QX
TX_I
TX_IX
FM
LOAD_SW
BAT_SAV
TX_STEP
QMOD_KEY
RX_I
RX_Q
A_D
FE_EN
AOC_CNT
RF_DET
AOC CONTROL CIRCUIT
AGC_RSSI
AFC
FREQ_ERROR
OSC_DIS
DISP_CS
FLASH_VPP
FLASH_EN
RAM_CS
BACKLIGHT
BOOM_MIC_DTCT
MAIN_BAT_SER_DAT
AUX_BAT_SER_DAT
SILENT ALERT LED
FLIP SWITCH
EE_HOLD
EE_EN
VSIM
VOLTAGE DOUBLER
5V SUPPLY
RX_2.75V
2.75V
TX_2.75V
2.75V SUPPLY
32KHz
SW_EXT_B+
EXT_B+ DISCONNECT CIRCUIT
ACCESSORY CONNECTOR
AUDIO_IN
AUDIO_OUT
BATT FDBK
MANTEST
3WB_RTN
CMP_LVL
MAIN_LVL
AUX_BAT_THERM
MAIN_BAT_THERM
AUX_FET
MAIN_FET
AUX_BAT
MAIN_BAT
AUX SWITCH
MAIN SWITCH
CHARGE CONTROL
AUX BATT
BAT_FDBK_COM
MAIN BAT
B+
DISCRETE AUDIO COMPONENTS
HEADSET DETECT CIRCUIT
BOOM/MIC
RSET_DTCT